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Electronic Business®

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Future chips: When to expect 4Mb DRAMs in volume PAGE 110

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Electronic Business

VOL. 14, NO. 1 JANUARY 1, 1988

FOR THE MANAGEMENT TEAM IN ELECTRONICS, COMPUTER AND SYSTEMS COMPANIES

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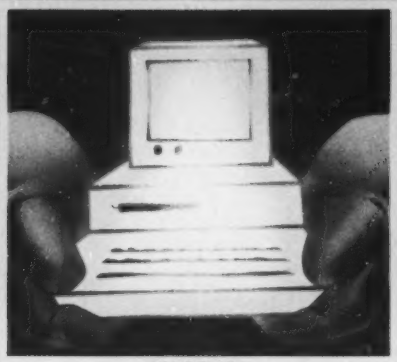

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Cover photograph: Curt Berner

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VBPA ABP

You shouldn't feel down with the Jones' Dow

If you do, you'll miss a good 1988, not to mention the advantages of a competitive dollar

Don't blame the stock market crash, which didn't happen until the fourth quarter of last year. Revenue had already moved onto a slower track during the third quarter for electronics companies in the United States. This past quarter wasn't too bad — revenues were ahead of the year-earlier quarter by 10%. But they undershot by a bit the level that, based on how well 1987 was going in the first half, Cahners Economics had forecast for the second. Same with profits. Instead of besting the third quarter of 1986 by almost 50%, the ELECTRONIC BUSINESS profits index was ahead by 37%.

Based on the not as good as expected third quarter, Cahners has reduced its estimate for revenue growth from 10% down to 8% in 1987, and has shaved a bit from its forecast for profits from a growth of 27% down to a still-substantial 25%. Similarly, but based on his model of U.S. production of electronic equipment, market researcher Ed Henderson estimated that U.S. production in 1987 grew by 6% over 1986, instead of the 7% he had forecast a quarter earlier.

The sample of 16 companies, whose financial results we use to compile the indexes, suggests that the third quarter's underperformance can be traced to two main reasons: weakness in military sales and IBM's slow recovery.

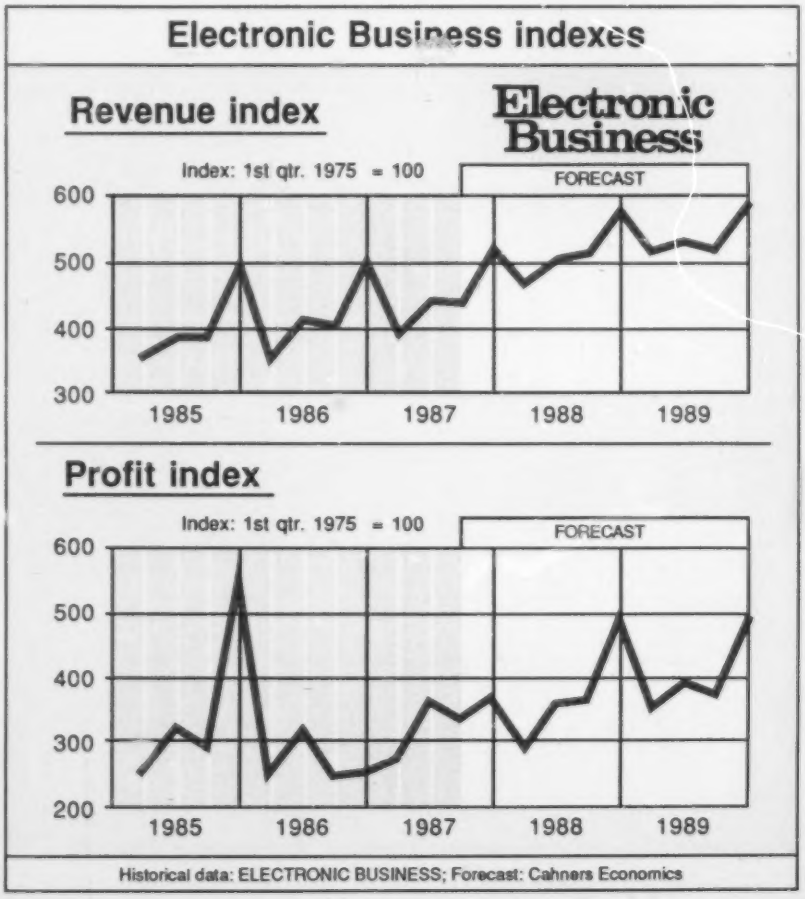
Some military programs are beginning to feel the impact of budget cuts. Even though the increasing electronics content of military systems is expected to offset those cuts, they cannot provide enough dollars to keep the growth at last year's rate. As for IBM, this company's revenue and profits represent a large portion of our index. Big Blue did not fare too badly in outright sales of equipment and did very well in sales of software, but declining maintenance and rental revenue held its third-quarter 7% above last year's.

Had the dollar remained at the same level as last year, however, IBM's revenue would have been lower. As 1987 came to an end, the company estimated that the cheap dollar added approximately 6% to revenue and 26% to profits.

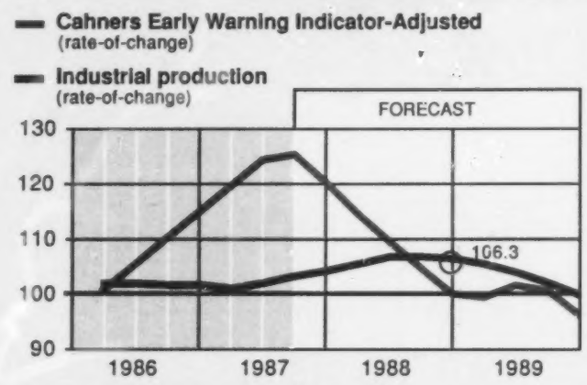
A competitive dollar can work for other companies, too. At the Producktronica Show in Munich, the largest show in the world devoted to production equipment for the electronics industry, European makers of such equipment were feeling the increasing competitive pressure from U.S. companies such as the Dynapert division of Emhart Corp. and Universal Instruments Corp., two leading U.S. manufacturers of equipment used to mount components onto printed circuit boards. The dollar not only helps their export revenue, but also their domestic sales.

The dollar, combined with a still-growing economy this year, will help in pushing the growth of our index for revenue to the 15% growth that Cahners forecasts for 1988, and 13% growth in profits. Henderson puts the growth in production for 1988 at 11%, the highest in recent years. Both forecasters see slower growth in the economy by 1989, and this is what the market drop is telling us.

ALBERTO SOCOLOVSKY



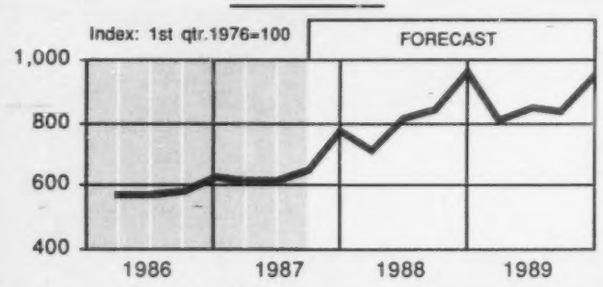
Economic indicators



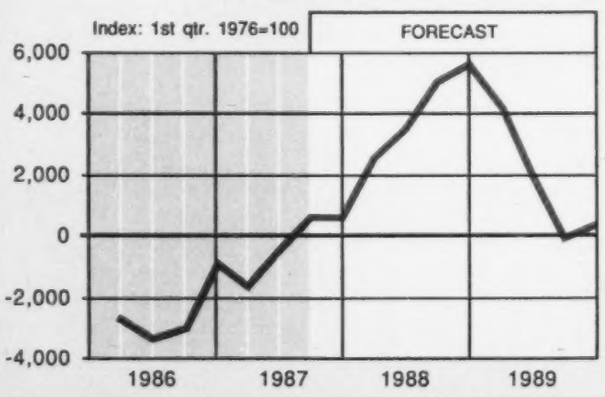
Historical data: Federal Reserve Board; Forecast: Cahners Economics

ATE indexes

Revenue



Profits



Historical data: ELECTRONIC BUSINESS; Forecast: Cahners Economics

Steady growth expected

The United States Index of Industrial Production, a coincident indicator of the U.S. economy, has been climbing steadily since the summer of 1986. During 1987's third quarter, output rose 2.1% from the prior quarter and was up 3.1% from the same date of the previous year. This slow and steady growth is expected to continue until this summer. Production is expected to rebound after a year and a half of sluggish growth, pushing production up 6.3% this year. The impetus for this upturn will be increasing U.S. exports, due to the decline in the value of the dollar, inventory replenishment and growth in business equipment investment.

The Cahners Early Warning Indicator (CEWI) has been adjusted by deleting the unusual effects of recent changes in financial markets. The adjusted indicator points to an upturn in the economic business cycle with the next business peak in August of 1988. The CEWI is a weighted average of housing starts, the Dow Jones Industrial Stock Index and the money supply (M2), deflated by the Consumer Price Index. The CEWI has proven to be an excellent tool in forecasting the turning points in the economic business cycles about 12 months in advance. The black curve is a plot of the 12-month rate of change Index of Industrial Production. That change over a 12-month period can be determined by comparison with the line at 100. For example, the 106.3 level forecast using the CEWI for the end of this year indicates that the average for all of 1988 should be 6.3% above 1987.

More information can be obtained from Elizabeth Baatz, economist, Cahners Economics Department, 275 Washington St., Newton, Mass. 02158.

ATE revenue and profit

The 1987 third quarter revenue for manufacturers of automatic test equipment rose 4.5% above the prior quarter and increased by an even stronger 11.3% over the year-ago quarter. A strong final quarter is expected to raise annual revenue by 13.2%. This year, the demand from computer and semiconductor manufacturers for automatic test equipment shows further signs of strengthening. Revenue is expected to rise a sharp 24.0% this year, followed by a much slower 3.0% increase in 1989.

ATE manufacturers returned to profitability during the third quarter of 1987. Not since the second quarter of 1985 has the ATE index shown positive earnings. Profits are expected to show healthy increases for the rest of 1987, through 1988, with a slowdown forecast in mid-1989.

APPLIANCES

Domestic help wanted: Electronic applicants welcome

If electronics parts suppliers can get prices down, they'll find a huge market in household appliances

The major appliances industry represents an already-large market for electronic components; already in use are membrane touch pads, microprocessors, timers and sensors. But it is a market whose potential has hardly been scratched. Observers see opportunities for everything from smart power chips to brushless motor controllers, and conservative estimates indicate that the business quickly could be worth hundreds of millions of dollars.

Most appliance executives express little doubt about the inevitability of electronic controls for their refrigerators, dishwashers, ranges, washers and dryers. The only question is how quickly such controls will penetrate to lower-priced models. Today, electronic features are exclusively at the high end of the product line.

Currently, best estimates are that between 1.5 million and 3 million major appliances use some type of electronic controls, but that number represents only 5% to 10% of the appliances soid last year. The Association of Home Appliance Manufacturers (AHAM), the industry's Chicago-based trade group, puts total factory shipments of conventional major appliances, excluding microwave ovens, at approximately 32.63 million units in 1986. HAM's figures do not include sales by General Electric Co., Somerville, N.J., the largest appliance manufacturer, which is not a member.) AHAM is predicting relatively flat major appliance sales for the next two years: 33.26 million units for 1987 and 33.03 million for 1988.

However, an AHAM spokesperson notes that the growth is "definitely" at the higher end, which now accounts for about 10% of total purchases and is growing toward 20%. The spokesperson adds: "Remember that 70% of appliance sales are replacements, and those are almost always a trade-up purchase." Manufacturer dollar sales of conventional appliances for 1986 totaled $8.83 billion, according to AHAM.

The use of electronics "has expanded quickly in the top-end products over the last couple of years," notes Douglas Ringger, manager of Maytag Corp.'s product test laboratory. "Appliances are fairly price-sensitive, however, so how quickly that reaches lower levels depends on the cost of components and consumer demand."

The introductions are being made cautiously. Kish Gursahaney, vice president for product development at White Consolidated Industries in Columbus, Ohio says: "No one is out to leapfrog the industry on this. Not when the consumer reaction to these appliances is: 'Explain to me why I need this.' "

"Eventually, all appliances will have advanced controls on them," states Robert Bowen, director of the new products center for Raytheon Co. Raytheon owns the Amana, Caloric, Magic Chef, Speed Queen and Modern Maid appliance lines.

"I think we will be seeing dramatic increases — barring a major change in the economy," Bowen continues. "If we revert back to tougher times, the high end will suffer. It will be hard to beat a mechanical switch that sells for $1.16. But right now the real opportunities are at the higher end," he says.

"Once you get electronics into a product that is not traditionally electronically based, the potential is immense"

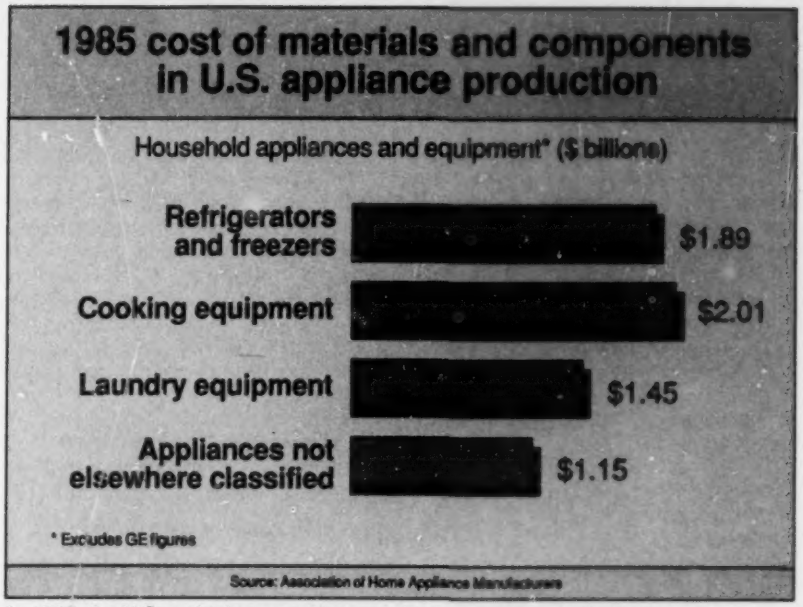
Daniel Artusi of Motorola

Julia Talcott

Change is coming

An executive on the supplier side argues the change is coming. "I've been involved with the appliance industry for over 10 years, and every year I think the time has come for electronics. But so far, it hasn't happened," says Daniel Artusi, director of marketing on power transistors, TMOS and SmartMOS products, for Motorola Inc.'s Phoenix, Arizona-based discrete and special technologies group. "But I see some indications now that the appliance industry is beginning to change."

One key change, he notes, is increased acceptance by the people who use those appliances and who shied away from electronic controls in the past. Artusi credits the widespread use of microwave ovens with accli-



In 1985, the U.S. major home appliance industry spent nearly $6.5 billion for components and materials — only 1% to 2% of it in electronics parts

mating users to electronic controls.

Currently, the components being used most frequently in appliances are membrane touch pads and the microprocessors that run them; timers, either programmed or temperature-controlled; temperature sensors and solenoid-operated motors. Estimates of the value of the electronic components in appliances varies. One executive puts it between $25 and $50 in a dishwasher; another says electronic diagnostic components add between $50 and $100 at retail to the price of a refrigerator, a little more to a dishwasher.

While component cost is a key issue, Raytheon's Bowen notes that direct price comparisons between mechanical and electronic controls are difficult. "Mechanical controls are very low-cost but only perform one function. Typically, with electronic controls, you get more functions for the dollar, but the controls cost more."

Similarly, White's Gursahaney says that suppliers should "work on functionality. If [electronic] components perform functions other than the ones mechanical controls do, then there is a justification to use them and a marketing reason to put them in."

Price parity with mechanical controls is almost a mandatory requirement for widespread use of electronics, Gursahaney adds. Describing prices today as more expensive, he says, "If the price was more in the ballpark of mechanical controls, there would be much broader usage." But today, he says: "There is not enough volume to bring the price down or enough incentive to spend the dollars to develop lower-priced controls."

Bowen of Raytheon makes a similar point when describing the limited interest by electronic suppliers in the appliance market to date. "Part of the problem is the appliance manufacturers cut such a tight deal. None of us makes an exorbitant profit. It all comes back to a volume issue," he says.

However, the enormous potential volume in appliances should be enough to make electronics suppliers consider the market, he says. "For example, there should be a lot of compatibility with people in the automobile industry because they already deal with high volumes and low costs. [Raytheon is] looking in all sorts of nonappliance areas for suppliers. I think any maker of components who wants to expand his business base should start exploring applications in appliances. Look at the volume compared to industrial applications," says Bowen.

Cost is key

Supplier executives agree that component cost is a key sticking point in the major appliance industry's conversion to electronics, but a problem that will be overcome.

The price spread now runs as high as two to one for electronic versus electromechanical components, says Stephen Ahrens, director of RCA Corp. standard IC products for GE. "Once we demonstrate we can get the cost down in volume, the appliance companies will do it," he said.

"The way I see it happening," continues Ahrens, "is on a custom basis. We are not working on, for example, an appliance control timer IC. Instead, we are working on custom circuits for specific appliance models. We are not currently in production on any custom ICs for the appliance market, but we will have such programs in production next year. For us, these are multimillion dollar opportunities."

Among the specific areas GE/RCA is working on are timers — "one of the least reliable parts in dishwashers and dryers," claims Ahrens — and water-level sensors for washing machines.

Daniel Artusi of Motorola agrees with the assessment of the appliance industry's potential as a market. "Once you get electronics into a product not traditionally electronically based, the potential is immense."

He feels the component cost will go down and available functions will increase, with the most widely used components likely to be microprocessors — one or two per appliance — and power devices, particularly power MOSFETs.

Several recent technological advances have appliance applications, Artusi feels. These include electrically erasable programmable read-only memory (EEPROMs), which will remain intact in a power failure without

Although the major appliances market will remain relatively flat in the next two years, it represents a wide-open opportunity for electronics parts suppliers. Less than 10% of the appliances sold last year used electronic controls

requiring a battery backup; discrete power MOSFETs to control the power supplied to motors; and smart power or power ICs to handle small motors such as the solenoids which lock doors, even though the main motors remain too powerful to control with a single IC.

Bob Benzer, new product planning manager for Motorola's bipolar analog IC division, sees near-future appliance applications for brushless motor controllers, particularly for such products as washing machines and dishwashers, and perhaps for refrigerator compressors. "Brushless motors provide a very cost-effective and efficient way to reverse motor direction and perhaps eliminate the mechanical transmission," he says.

Best bet

His associate, Jade Alberkrack, a senior staff applications engineer, predicts that the washing machine will be the first on the market with a brushless motor control. Says Alberkrack: "You can replace the transmission and control the agitation speed. And once you get a processor in there, like the top-of-the-line washers now have, it can communicate directly with a brushless motor IC."

Brushless motors, they acknowledge, cost more than the induction motors currently used in North American appliances. However, they add, brushless motors provide better speed control, and would make appliances compatible with power sources in European and Asian markets.

Several appliance and supplier executives draw analogies between the appliance and automobile businesses regarding the conversion to electronically featured products.

Both industries are fairly concentrated. The major appliances industry has about 20 well-known brand names but only five large producers, the result of a wave of mergers and acquisitions in recent years. The top two companies, General Electric and Whirlpool Corp., each sell more than $4 billion in appliances annually. They are followed, in order, by White Consolidated Industries, now owned by AB Electrolux of Sweden; Maytag Corp. and Raytheon.

"Any maker of components who wants to expand should start exploring applications in appliances. Look at the volume"

Robert Bowen of Raytheon

Like the auto makers in the past, the appliance companies have an enormous capital investment in plants geared to electromechanically controlled products. That capitalization is one reason for the very slow introduction of electronic components in appliances, believes Howard Abramowitz, vice president of the electronic business group at El Segundo, California-based International Rectifier Corp.

Motorola's Artusi feels that the automotive analogy may go further, to include the gasoline shortages of the early 1970s. "I think three to four years from now, the utility companies will approach 100% capacity and there will be big pressure to lower the energy levels of all appliances in the home. Electronics can do things like power control," he says. "Electronic controls won't be in over 50% of the appliance volume in the next three to five years unless we see a big push for energy efficiency," Artusi predicts.

Since their demand for electronic components is still relatively small, appliance manufacturers report little difficulty in obtaining supplies to meet their needs. To date, however, many are sticking with traditional suppliers that have moved into the electronics area. And, semiconductor manufacturers say they are working with both appliance companies and their parts suppliers.

Wanted: Willing partners

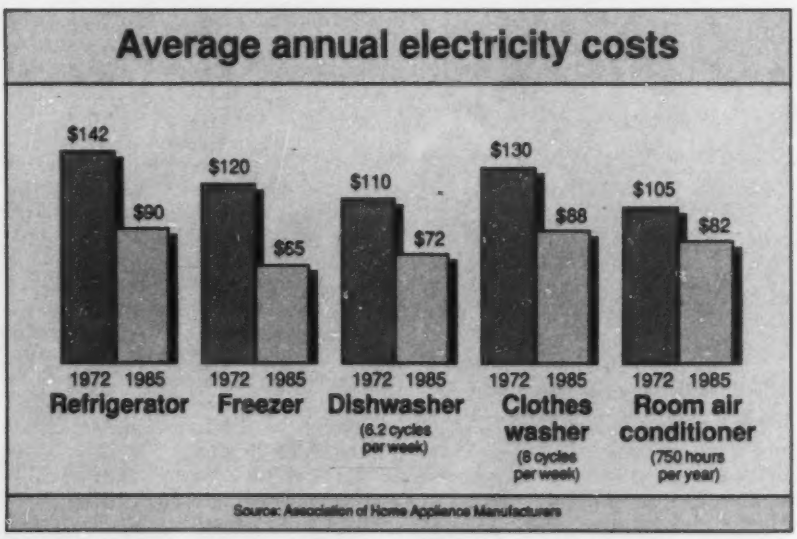
"Appliances is a very limited market for suppliers now," notes White's Gursahaney. "The problem is finding the partners willing to invest in the future. Most suppliers want a payback now, and it's not there." White, he says, is currently working primarily with the firms which also supply mechanical controls: Robertshaw Controlled Co. and Ranco Inc.

Roper Corp. is a Georgia-based range manufacturer which sells about 75% of its production to Sears under the Kenmore brand. The company has been in the lead in using electronic components — particularly clocks and timers, but also oven controls — and in putting them on midpriced ranges. Roper works with two suppliers on designing the controls it wants: the Semicon division of Robertshaw and Goldstar Instruments in Korea.

Douglas Ringger of Maytag says his firm does its software in-house. "We design the chip and the whole control and then go to a manufacturer. We want to be very involved to control the quality," he says. Maytag's sources are domestic.

NANCY BRUMBACK

Brumback is a Boston-based business writer



New appliances cost less to operate. Observers believe that electronic controls can help lower their energy usage further to meet predicted power shortages

SEMICONDUCTORS

The ASIC market: Paradise yesterday, war zone today

In 1982, emerging ASIC markets were good to chip start-ups. But now the talk is of shakeout and big-league competition

Service was chic in the semiconductor industry for a long time. The service-based application-specific IC business was considered so highbrow that its players looked down on the commodity market as a Sak's Fifth Avenue store would view competition from a K-Mart.

"Here at last was a Holy Grail semiconductor industry in ASICs," says Xilinx marketing vice president Wes Patterson. "We were seduced into it. The venture capitalists were in a frenzy because now you could sell product that would be priced for its value."

That era is officially over. During the past eight years, over 30% of all semiconductor start-ups formed were in the ASIC business. During the same time, practically every major company announced its intention to enter the application-specific arena, so now everyone seems to be in on the act. A minimum of 100 companies are in the ASIC business, all trying to get a piece of a market valued at $2.8 billion in 1987, according to market research firm Dataquest Inc.

Is that a problem? Indeed. In 1986 just nine ASIC suppliers had 70% of the revenue, according to Technology Research Group, and that percentage is increasing. That still leaves at least 90 suppliers vying for 30% of the market. "There are really only 10 players in the ASIC business," asserts George Wells, president of LSI Logic Corp., one of that elite. "The others are stragglers."

So companies who were there first do not necessarily have the leg up on everyone else. And suddenly the stakes have been raised as falling prices, commodity mentalities and brutal competition mean that the ASIC marketplace is an uptown playground no more.

Not surprisingly, then, the ASIC shakeout has already begun. Almost one dozen small companies have withdrawn from the ASIC market completely, including California Devices Inc., Universal Semiconductor Inc. and Telmos.

The shakeout is likely to continue, as changing market dynamics and economic conditions force small start-ups to either differentiate themselves or face life-threatening price squeezes and competition.

Many start-ups based their business plans around the ability to deliver superior service. Three to four years ago that was a viable idea, but today service is little more than a commodity, or as one wry observer said, the "great equalizer." Every company can offer service, so those offering that but little else are getting left behind in the scramble for market share.

"Service isn't winning designs anymore," says Doug Razer, ASICs strategic marketing manager at Texas Instruments. So, although the ASICs market is predicted to mushroom to $10.2 billion by 1992, the real picture for many companies is not nearly so rosy — or profitable.

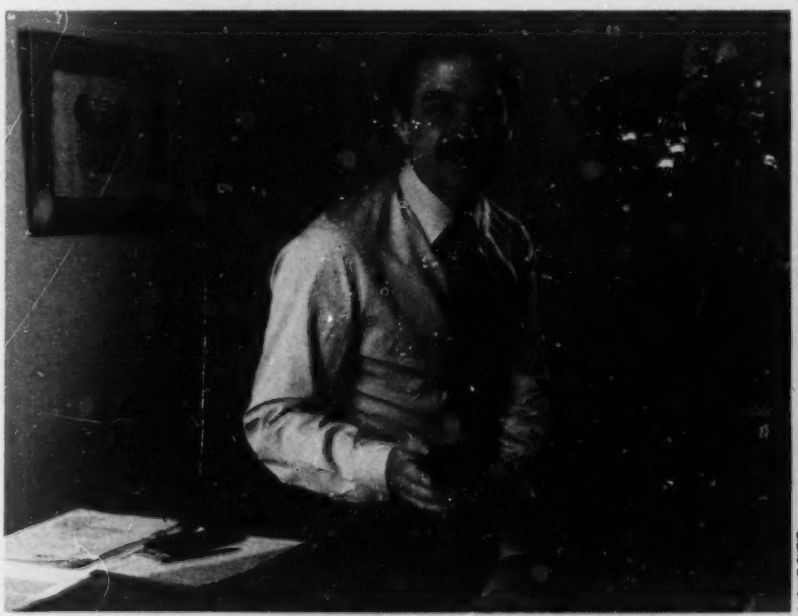
First, and probably foremost, it is difficult to make money in a semicustom business. Customers generally want small numbers of parts, and often need a large amount of handholding, neither of which is inherently profitable.

Fujitsu America Inc., for example, would really like to be a virtual ASIC foundry for its customers, says ASICs marketing manager Gary Hess, because it is difficult to make money on the design and engineering side. At TI, the picture is the same, according to Razer; he says he is trying to get his engineers away from doing simulation and capture for customers so that TI can be more like a design foundry.

But the handholding is not the only reason that companies don't make money in ASICs. Gate arrays, the single largest segment of the ASICs market, are as cutthroat as the memory business ever was, only there are even more players. And like the memory business, the Japanese are a major force in gate arrays, and can afford to apply the price pressure in the hopes of a more long-term market share gain.

Gate array prices have fallen to 0.3 cents per gate, according to Technology Research Group, and the low end of the market — under 10,000 gates — will continue to fall, TRG says.

"It's difficult to make money at the



Liane Enkelis

XILINX'S PATTERSON: "In 1982, the ASICs business was a Garden of Eden"

low end," LSI's Wells says. VLSI Technology, a more recent entry into the gate array market, had lost money on the products until last quarter, says chairman Al Stein. "We are in the black for the first time in this business," Stein says. "It should have a dramatic impact on our profitability."

"If you take away the nonrecurring engineering expenses and sales of the software, it is not a very profitable area to be in," Technology Research Group's Andrew Rappaport contends.

If these large companies are struggling in the gate array market, it is difficult to imagine what smaller companies without deep pockets are doing. And analysts say that the bulk of the smaller players in the ASIC business are in the gate array market — primarily in the low gate count sector.

It is not all gloom at the low end, however. "The low end demand is going to be there," Dataquest Inc. senior analyst Andrew Prophet contends, "but it is a matter of how big a slice of the pie these companies want for themselves."

Only 5% of the market is likely to be at the high end of the gate count at any one time, Rappaport says. But those early adapters tend to outpace the rest of the customer base in density by 25 to 1. In other words, if the top 5% are using 100,000 gate parts, the rest of the industry is probably still at the 4,000 gate level, or not much more.

But will those low-end opportunities be available to small companies that lack their own fab facilities, design software and expertise? Probably not, because large companies have entered the market, and seem to have every intention of remaining for the long term.

The big boys arrive

Although some large companies entered rather late, there are very few reasons to believe that they will not succeed, or that their intentions aren't serious. Motorola Inc., for example, has been a leader in ECL gate arrays for some time, although it has had a slow start in the CMOS area. But companies like Texas Instruments Inc. have reached leadership positions in the standard cell market and are branching out into gate arrays.

As these companies increase their commitment to ASICs, it would appear that the market is ready to buy from them. According to TRG, the size of the typical supplier serving the ASIC market has grown much faster than the industry as a whole each year, meaning that small suppliers are getting squeezed out of the business by larger competitors.

LSI's **WELLS:** "It's difficult to make money at the low end of the ASICs market"

In 1986, just nine ASIC players had 70% of the revenue. That leaves at least 90 suppliers vying for 30% of the market

Yet many of the old-line ASIC players, such as LSI Logic and VLSI Technology, are skeptical of the ability of large companies to make it in a service-oriented, noncommodity business. "The newcomers may look successful," LSI's Wells warns, "but they were doing it to turn their fabs to something worthwhile [during the downturn]. The big guns may move away from ASICs [when times get better]."

"There are a lot of barriers in this market," Stein adds. "I think some [big companies] will abandon the effort, particularly if the semiconductor industry is relatively strong. They have other products that might be more profitable."

But large companies have a vested interest in participating in ASICs. Studies show that customers want proprietary building blocks from which they can leverage their ASIC strategy. Companies like Motorola, Intel and TI, with large percentages of proprietary products, particularly microprocessors and related peripherals, stand to lose a lot if they do not protect their investments.

At Fujitsu, the gate array business is continuing to grow at a rate in excess of 50% over the previous year, and the company is increasing its penetration in the U.S. market, Hess says. Fujitsu is currently going after both the high performance, high-density market, as well as the high volume, low- to medium-density market, Hess says. "It's the 80-20 rule. Twenty percent of the customers have 80% of the consumption. Those people want to deal with someone who is a full-service supplier."

Intel is actually in all three of the ASIC businesses: standard cells, gate arrays and programmable logic devices (PLDs). ASICs general manager Jack Carsten says that Intel is in it for the long term, despite the fact that all three groups only generated $25 million in revenue in 1987. "We're doing it," he says, "but it is painful growing." One area that Intel struggles with is the heavy software requirement in the standard cell arena. Carsten says the company has been forced to do its own software, and that is taking time. The other major challenge has been to change the com-

Liane Sinkelis

pany's attitude about proprietary products.

"In order to be a good ASICs company, you have to have the mindset of working with people," Carsten says. "At Intel we have really viewed our technology as our family jewels, and that to give our secrets away to customers is like selling the family birthright. It is difficult to see how we could make our customers experts without revealing our secrets. We can't, and we've had to change the attitude of the company about that from the top down."

"It's a clear trend," says TI's Razer about ASICs. "Customers want more and need more control." So TI's strategy is to play to this need for control and offer customers standard products with which they are already familiar, such as ASIC products in the digital signal processing area. "Companies who give customers standard products [that] the customer is already familiar with stand a good chance of lasting out in the market."

VLSI is trying to move itself into the next level of gate arrays, with its recently introduced 100,000-gate product. But Wells points out that the company still does a lot of business in the low end, and that manufacturing expertise and streamlining have helped to make the business less of a drag on profitability. "There is really a good business in software right now," he adds, noting that his company has made a name for itself as a top designer of ASIC software and libraries.

"If you have 30 companies in a niche, it isn't a niche anymore," asserts David Angel, a principal in DQ Alliances, a technology alliances firm. The ASIC sector is no different than any other portion of the market right now: small companies must find something they do better than anyone else and then stick to it.

Survival of the smartest

There are several ways to find successful niches however, and some do not even require large amounts of capital investment.

Low-end gate arrays are not a longevity business, but "programmable" gate array vendor Xilinx has probably hit on a solid long-term strategy. Xilinx makes programmable logic arrays (PLAs), which are essentially customer- or user-specific ICs, since the customers do the programming themselves. So what Xilinx has to offer is essentially a custom product (in fact, many argue that PLAs or PLDs are not really ASICs, but the jury is still out) but with all of the flexibility and user configurability necessary to solve the needs of an ASIC world. And Xilinx doesn't need a fab.

Small companies must find something they do better than anyone else and stick to it

"In 1982, the ASICs business was a garden of Eden," Xilinx's Patterson says. "We really believed what we were saying then." But, Patterson says that the young ASIC industry did not really understand the cost implications of a very custom business. "The costs just kill you if you're only building 1,000 or 10,000 parts at one time." But now Xilinx has the solution in the user programmable area, Patterson contends. "User programmable chips will be 30% of the ASICs market by 1990, and the average selling price will be two times higher per gate than standard gate arrays."

Another player, International Microelectronic Products Inc. (IMP), refocused its ASIC strategy to put itself on more sure footing in the long term. When company executives looked around at the market, they saw a need for mixed analog/digital circuits in the ASICs environment. IMP has moved strongly into that niche, has also brought the world of analog design to software for the first time. "In order to make it, you have to be very good at something," strategic marketing director Peter Hillen says. "You have to control your own destiny. We are in a segment of the market that has the highest growth potential."

All-layer custom is the market niche that Sierra Semiconductor has pursued, and according to president James Diller, that is a segment of the market that is strong and getting stronger. "You want to be in an area where you can lead," Diller emphasizes. Sierra also saw the potential of mixed analog/digital and is aggressively pursuing it as well as a number of standard application-specific, very fast memory products.

VALERIE RICE

Estimated worldwide consumption of ASICs

($ millions)

	1987	1988	1989	1990	1991	1992	Compound annual growth
Gate arrays	$2,406.6	$3,163.9	$3,773.6	$4,851.2	$6,175.4	$7,832.2	26.6%
Programmable logic ICs	416.0	582.7	764.0	917.8	1,058.6	1,160.8	22.7%
Total semicustom ICs	**$2,822.6**	**$3,746.6**	**$4,537.6**	**$5,769.0**	**$7,234.0**	**$8,993.0**	**26.1%**
Cell-based ICs	919.4	1,262.7	1,537.6	2,090.7	2,765.8	3,611.3	31.5%
Full-custom ICs	2,283.6	2,395.1	2,204.9	2,148.1	2,115.7	2,087.6	-1.8%
Total custom ICs	**$3,203.0**	**$3,657.8**	**$3,742.5**	**$4,238.8**	**$4,901.5**	**$5,698.9**	**12.2%**
Total application-specific ICs	**$6,026.6**	**$7,404.4**	**$8,2801**	**$10,007.8**	**$12,135.5**	**$14,691.9**	**19.5%**

Source: Dataquest Inc.

VENTURE CAPITAL

The hot new companies of 1988

What makes a start-up hot, and what makes it not? Here's what the venture capital community replied

By Beth Karlin

When the stock market crashed in October, emerging high-technology company executives and venture capitalists held their collective breath. Like most in the financial community, they wondered what would be the long-term impact of Black Monday and the ensuing market chaos. When the dust settled, however, the future of venture capital — and high-tech start-ups — remained promising.

The only real concern was whether today's hot new crop of start-ups will have difficulty going public when the time comes. "The initial public offering market is dead now," Kent Stout, partner in consulting company Deloitte Haskins & Sells' high-technology group in Boston, said shortly after the crash. "If this continues for three or four months, it could be a real problem."

But for emerging companies, that long-range fear was overshadowed by the unbridled enthusiasm often seen in technology pioneers. Flush with the success of gaining investor backing for their products, start-up executives were more interested in the near term. Hoping to repeat the successes of the venture capital-backed stars of the 1970s, the new wave of start-ups stood poised for takeoff.

To find out which firms would likely survive market entry and prosper, ELECTRONIC BUSINESS recently polled about 125 venture capitalists with sizable investments in the electronics industry. In the questionnaire, we asked them to name the most promising start-ups in their portfolios. While our listing on the accompanying pages is by no means complete, the nominees do provide us with a sampling of what many venture capitalists regard as the hot new companies.

In addition, the venture capitalists' responses revealed a broad range of emerging new technologies. Even though products varied widely, most fell into a few general categories:

- **Semiconductors**. Highlighted were BiCMOS products, which combine bipolar and CMOS technologies into one wafer fabrication process; and bipolar VLSI devices.

There may be turmoil on Wall Street but venture capitalists continue to invest in emerging technologies

UPI/Bettmann Newsphotos

- **Minisupercomputers**. High-speed computing for scientific and engineering applications is getting a boost from venture capital investment.
- **Software**. Much of the investment is centered on personal computer software, although the technologies involved run the gamut of applications, everything from design of VLSI devices to software development.
- **Telecommunications**. Local area networks, fiber-optic transmission systems and high-speed modems were frequently cited as fast-track technologies.
- **Imaging systems**. From medical to manufacturing applications, there appears to be ample funding for firms involved in the capture, storage and manipulation of images.

However, while investor interest is strong in these areas, it is not limited to these technologies. Other companies cited in our poll of venture capitalists included Hypres Inc., an Elmsford, N.Y., firm that uses superconductivity for its line of very fast oscilloscopes; and Karlin & Collins Inc., Sunnyvale, Calif., which sells electronic routing systems that give automobile drivers step-by-step directions from one location to another.

And Investment Support Systems, Bloomfield, N.J., has developed software for trading financial futures and options. "This accounting software allows traders to better monitor their positions," says Michael Collins, an investment analyst with TA Associates, a Boston-based

Marty Braun

Venture capitalists handled plenty of hot technology last year. In all, they invested about $3 billion in technology firms in 1987

venture capital firm.

In all, venture capitalists invested about $3 billion in high-, low- and middle-technology firms in 1987, according to *Venture Capital Journal*, up from about $2.9 billion the previous year. When deciding how to invest those funds, venture capitalists evaluate not only the product and the potential market, but the management. Indeed, "the management team is the most important consideration," according to Nissan Boury, managing director of Warburg Pincus Ventures Inc., New York City. "A superb product with poor management usually is no good. But an average product with superb management has a chance."

If our list is any indication, the executive rosters of the new hot companies tend to read like a *Who's Who* of corporate America. Most leave successful firms, lured by a vision of the new American dream — running their own business. Then they have to convince venture capitalists — or other sources of financing — that their vision can become reality. Ultimately, in deciding to fund a company, says TA Associates' Collins: "We just have to believe in their dreams."

A BIT of luck

George Wilson, Kenneth Schlotzhauer and James Picket, for example, all worked together at Tektronix Inc. and cofounded Bipolar Integrated Technology Inc. (BIT), in Beaverton, Ore. Their goal is to convert unbelievers to the advantages of bipolar technology. The company's proprietary "BIT1" process offers high performance at low power. Using the same fabrication techniques as other bipolor and MOS technologies, BIT has achieved VLSI at bipolar emitter-coupled logic speeds.

BIT recently wooed Stephen Cooper away from his job as president and chief operating officer of Silicon Systems Inc. to become chief executive officer and chairman. He replaced Wilson, who continues as president, chief technical officer and member of the board. "Cooper can take us through the transition from the development stage to volume manufacturing," says Les Soltesz, marketing vice president. "We expect to grow to $100 million over the next four or five years," from under $1 million in fiscal 1987, ended in June.

Seed money from Analog Devices Inc. and financing from the likes of BancBoston Ventures, Iterven Partners, Raytheon Co. and Union Venture has amounted to $24.3 million to date. Now BIT is considering going public. But, says Cooper, "current market conditions could affect the timing of that offering."

But BIT is not alone. Many startups are expected to put on hold plans to raise capital in the stock market. Interest in public offerings has dimmed along with confidence in the market. This is both good news and bad news for venture capitalists. The good news is that they will likely do more second-round and later financ-

ing for companies that decide not to go public just yet. And they will make those investments at a time when many companies are undervalued. The bad news is that the market has always represented the big payoff for early investors — the exit vehicle for them to sell off shares and make millions. Now they may have to wait longer. But venture capital has always been a longer term, higher risk investment than other methods of financing.

Take the case of Saratoga Semiconductor Corp., Cupertino, Calif. Last March, the firm raised $17 million in its third round of venture placement, on top of $11.5 million raised in two previous financings. "The enthusiasm among investors was tremendous," says Edward Browder, president. But investors also concur. "Our money speaks better than words," says Gunnar Hurtig, general partner of Weiss, Peck and Greer, a San Francisco venture capital firm. "We were the lead investors in the first and second rounds of financing — and have committed another $3 million in the third round. That should speak highly of our confidence in both Saratoga Semiconductor's business concept and in its management team."

Interest in public offerings has dimmed along with confidence in the stock market

At the core of Saratoga Semiconductor's business concept is BiCMOS, a new process technology that offers the best of both bipolar and CMOS. "Speed and complexity are the two main ingredients required by our customers," says Andrew Wang, chairman and cofounder and previously director of component technology at Amdahl Corp. The company is targeting high-end applications in the military, computer and communications sectors.

"We build the Corvettes of semiconductors," says president Edward Browder, formerly vice president and general manager of the advanced bipolar products division of Fairchild Semiconductor Corp. The cofounders started up Saratoga in late 1985 with the help of 18 employees from Amdahl's failed semiconductor operation — with Amdahl's blessing.

Enticing venture capitalists to invest isn't always easy. Aries Technology Inc. decided the best way to get venture investment was to collect evidence proving that it had developed a product that the market craved. And the best way to do that, says Larry McArthur, president of the Lowell, Mass., firm was to have the customers develop the product in the first place. In Aries' case, the product is its ConceptStation series of mechanical computer-aided engineering software. "It was definitely market-designed product," says McArthur.

Aries spent two years researching potential users, repeatedly visiting 40 *Fortune* 200 companies to find out what engineers wanted. The company hoped to do for mechanical engineering what firms like Daisy Systems Corp. and Mentor Graphics Corp. did for electronics design. "We collected reams and reams of data," says McArthur. So, when venture capitalists asked Aries why it thought it would be successful, he explains, "We could open up our file cabinets and hit them with real-life data. It was amazingly powerful."

As a result, Aries has, since June, raised $24.5 million. And, thanks to a $5 million investment by the Dutch MIP Equity Fund and a $2 million investment by a Japanese company, Aries is moving to Europe and the Far East. Worldwide sales of mechanical computer-aided engineering hardware and software will reach $2.2 billion by 1991, according to Dataquest Inc., a San Jose market research company.

Getting first-round financing

Getting first-round financing can be especially hard, since investors often prefer companies with demonstrated success. Business Software Technology Inc. (BST) waited two years from its start in early 1984 before it went to venture capitalists to finance an acquisition. "By then, we were profitable and management had a proven track record," says John Burton, executive vice president of the Westborough, Mass., firm. Venture capitalists had already begun to notice BST's progress and were ready to invest. "It took us less than 120 days to get the money we needed to buy Condor Technology," he says.

In the beginning, BST founders preferred to make do with profits from consulting services while developing software products to automate change management in the IBM mainframe environment. "We were bootstrapping profitable revenue as consultants to users of database management systems," explains Burton. BST's products enable users of complex and sophisticated information systems to use automation to maintain, document and control systems changes. BST, which had revenue of more than $5 million in 1987, is looking for other acquisitions to expand its product line.

Fiber-optic products

One area that's getting a lot of attention these days is fiber-optic products. With venture capital backing of $2.5 million, for example, Intelco Corp., Acton, Mass., started up in 1985 to design, develop and manufacture state-of-the-art, high-performance test equipment for fiber optic and high-speed digital telecommunications customers. And Licom Inc., Herndon, Va., got venture capital backing to make fiber-optic transmission equipment.

Last February, Licom hired Robert McIntyre as president and chief executive officer. Before joining Licom, McIntyre held the same posts at Siemens Transmission Systems Inc. McIntyre, like many other start-up executives, opted for the challenge and fluidity of an emerging company over the often-staid environment of a large bureaucracy. "I felt the need to work with a company in its growing stage, rather than its contracting stage," McIntyre said when he left Siemens.

Getting first-round financing can be very hard: Investors often prefer firms with demonstrated success

Indeed, it is that desire to make a difference that lures many successful executives away from their secure jobs to high-risk, potentially high-reward opportunities. "It is the new American culture," says TA Associates Collins. "The American dream is no longer just to rise up in a large corporation. The American dream these days is to do your own thing."

On the following pages is our list of this year's promising start-up companies. This is not a conclusive list of U.S. start-ups but a representation of companies that major venture capitalists have endorsed for 1988.

Promising start-ups: A to Z

ELECTRONIC BUSINESS has asked the U.S. venture capital community to nominate the start-up companies which they believe to be the most promising for 1988. We polled over 125 venture capitalists to determine this year's hot new companies. The only other necessary criterion, besides being "hot," was that each nominee should have been incorporated no earlier than Jan. 1, 1984. Each start-up was sent a questionnaire to provide us with additional information on its product and background.

The products range from intelligent pay phones to desktop film recorders. The companies' total equity figures range from less than $1 million to over $30 million. According to the leading venture capitalists, the following 38 companies have demonstrated promising potential for this year.

MARY DONOVAN

Aries Technology Inc.

Larry McArthur
600 Suffolk Street
Lowell, Mass. 01854
Phone: (617) 453-5310
Incorporation date: 11/84
Major financial backers: ABS Ventures Limited Partnership; Alex. Brown & Sons EGA Limited Partnership; Eastech Management Co.; First Capital Corporation of Chicago; PruTech II and PruTech III, funds managed by R&D Funding Corp., a wholly owned subsidiary of the Bache Group; PruTech Project Development Partnership; Citicorp Investment Management; Edelson Technology Partners; Cummins Venture Corp.; MIP Equity Fund
Product: Desktop CAE computer systems
Date available: 6/87
Total equity invested: $22.5 million

ASIX Systems Corp.

Wayne Pittenger
47338 Fremont Boulevard
Fremont, Calif. 94538
Phone: (415) 656-8664
Incorporation date: 10/84
Major financial backers: Paragon Partners, Citicorp Venture Limited, Vista Ventures, Rust Venture L.P., O'Rien Ventures, Republicbank, North Carolina Bank (NCB) Venture L.P., and ECI Ventures (London)
Product: Automatic test systems focused on ASICs for production and design verification
Date available: 9/87
Total equity invested: $8.5 million (second round)

Atherton Technology Inc.

Ram Banin
1333 Bordeaux Drive
Sunnyvale, Calif. 94089
Phone: (408) 734-9822
Incorporation date: 1/86
Major financial backers: Kleiner Perkins Caufield Byers, Mayfield Fund, Menlo Ventures, Morgan Stanley
Product: An integration and portability platform for large engineering projects used to tie together multivendor software tools into one integrated project support environment. The company will also supply specialized tools
Date available: 9/87
Total equity invested: $7 million

BIT - Bipolar Integrated Technology Inc.

George Wilson
1050 N.W. Compton Drive
Beaverton, Ore. 97006
Phone: (503) 629-5490
Incorporation date:
Major financial backers: Analog Devices, Interven Partners, Raytheon Corp., Harvard Management, Banc-Boston
Product: Bipolar VLSI, DSP & technical computing chips
Date available: 9/86
Total equity invested: $24.3 million

Business Software Technology

Nick C. Rini
Westborough Executive Park
114 Turnpike Road
Westborough, Mass. 01581
Phone: (617) 870-1900
Incorporation date: 2/84
Major financial backers: NA
Product: Automated change control for software development
Date available: Early 1987
Total equity invested: NA

Carlyle Systems

Vincent F. Titolo
5750 Hollis Street
Emeryville, Calif. 94608
Phone: (415) 654-2600
Incorporation date: 6/84
Major financial backers: Drexel Burnham Lambert, Union Bank
Product: Turnkey automation systems for libraries and other database management/information retrieval applications
Date available: 6/84
Total equity invested: $3 million

Chromaline Technologies Inc.

Richard B. Tompane
445 South San Antonio Road
Los Altos, Calif. 94002
Phone: (415) 949-5544
Incorporation date: 3/86
Major financial backers: Alpha Part-

ners, Venrock, Arthur Rich, Prince Ventures, Cornerstone Ventures, Apple Computer
Product: 35mm desktop film recorder for making presentation graphics
Date available: Early 1988
Total equity invested: $5 million

Crystal Semiconductor Corp.

James H. Clardy
2028 East St. Elmo Road
Austin, Texas 78744
Phone: (512) 445-7222
Incorporation date: 10/84
Major financial backers: Sevin, Rosen, Bayless, Borovoy; Interwest; Kleiner Perkins Caufield Byers; Berry CASH Southwest Partners
Product: Analog integrated circuits
Date available: 5/86
Total equity invested: $14.7 million

Cydrome Inc.

André Schwager
1589 Centre Pointe Drive
Milpitas, Calif. 95035
Phone: (408) 945-6300
Incorporation date: 5/84
Major financial backers: Aswet Management Co., Institutional Venture, U.S. Venture Partners (seed and first round). Abbingworth Plc, Bryan & Edwards, General Electric Venture Capital Corp., MRI Ventures, Nazem & Co., Oscco Ventures, Prime Computer Inc., Security Pacific Capital Corp., Stanford University Engineering Fund, UNC Ventures, Walden Ventures (second round). N.Y. Life Insurance (third round)
Product: Supercomputer for engineering and scientific, numerical intensive computing
Date available: To be announced
Total equity invested: $32.9 million

Doelz Networks Inc.

A.C. Tedesco
9501 Jeronimo Road
Irvine, Calif. 92718
Phone: (714) 770-1221
Incorporation date: 1/87
Major financial backers: Brentwood, Alex. Brown & Sons, Citicorp, Hambrecht & Quist, J.H. Whitney, Rothschild
Product: A complete data transport network for companies with multiple networks or multiple networking needs and dispersed locations
Date available: 1987
Total equity invested: $32 million

Gamma Technology

Michael Lutz
2452 Embarcadero Way
Palo Alto, Calif. 94303
Phone: (415) 856-7421
Incorporation date: 1/85
Major financial backers: First Analysis Corp.
Product: Facsimile communications for personal computers
Date available: 6/86
Total equity invested: $380,000

Hologic Inc.

Dave Ellenbogen
200 Prospect Street
Waltham, Mass. 02154
Phone: (617) 893-5100
Incorporation date: 10/85
Major financial backers: Burr, Egan, Deleage & Co.
Product: Bone densitometer for osteoporosis screening
Date available: 10/87
Total equity invested: $3.5 million

Intelco Corp.

George Chryssis
8 Craig Road
Acton, Mass. 01720
Phone: (617) 264-4485
Incorporation date: 1/85
Major financial backers: Burr, Egan & Deleage, MCRC
Product: Fiber-optic and high speed digital telecommunication test instruments
Date available: 1/86
Total equity invested: $2.5 million

Microwave Modules and Devices

Joe Johnson
550 Ellis Street
Mountain View, Calif. 94043
Phone: (415) 961-1473
Incorporation date: 4/84
Major financial backers: Bay Partners, Hambrecht & Quist, Grace Venture, Montgomery Ventures, Paine Webber, New Enterprise Associates
Product: High-power RF and microwave amplifiers and amplifier subassemblies for both defense and commerical applications
Date available: 4/84
Total equity invested: $10.7 million

Multiflow Computer Inc.

Donald Eckdahl
175 North Main Street
Branford, Conn. 06405
Phone: (203) 488-6090
Incorporation date: 4/84
Major financial backers: Aeneas Venture Corp.; Harvard Management Co.; Aetna Life and Casualty; Alan Patricof Associates; Alex. Brown & Sons; Bessemer Venture Partners; E.G.C. Limited Partnership; Fairfield Venture Partners; General Electric Venture Capital Corp.; Inco Venture Capital Management; Investech L.P.; John Hancock Venture Capital Management; L.F. Rothschild, Unterberg, Towbin; Morgan, Holland Venture Corp.; Olivetti Partners; Paine Webber Ventures; Regional Financial Enterprises; T. Rowe Price Threshold Funds; Technology Transitions Inc.; Tessler and Cloherty
Product: Minisupercomputers
Date available: 4/87 (another to be announced 1/88)
Total equity invested: $35 million

Natural Intelligence Corp.

Stephen K. Holford
200 Fifth Avenue
Waltham, Mass. 02154
Phone: (617) 890-2440
Incorporation date: 9/85
Major financial backers: Inco Venture Capital
Product: Hardware and software that allow development of Lisp performance signal processing and real-time computing applications using technical workstations and networked computers
Date available: Early 1988
Total equity invested: $1 million

Optigraphics Corp.

James D. Wylie
9339 Carroll Park Drive

San Diego, Calif. 92121
Phone: (619) 292-6060
Incorporation date: 4/84
Major financial backers: Merrill Lynch, BMW, Texaco, National Bank of Paris, Tenneco
Product: Graphics systems to capture, digitize and store images such as original drawings, maps and photos
Date available: 1985; 1986 (two product versions)
Total equity invested: NA

Performance Semiconductor Corp.

Thomas A. Longo
1610 East Weddell Drive
Sunnyvale, Calif. 94089
Phone: (408) 734-8200
Incorporation date: 10/84
Major financial backers: Brentwood Associates, Northwest Fund, VS Ventures, Asset Management, Advanced Technical Venture, DSV, Tayler & Turner, Westinghouse Electric Corp., Harvard Management, IAI, North Star, Seymour Cray
Product: High-end 16- and 32-bit microprocessors. Up to 256K static RAMs. Very fast logic parts
Date available: 1986, 1987 and 3/88
Total equity invested: $32.5 million

Precision Image Corp.

Gary Hughes
501 Chesapeake Drive
Redwood City, Calif. 94063
Phone: (415) 366-8900
Incorporation date: 2/85
Major financial backers: Sequoia Capital, Cross Point Venture Partners, Southern California Ventures
Product: Color electrostatic plotter systems
Date available: 1/87
Total equity invested: $12 million

Ready Systems

(Formerly Hunter & Ready)
Aryeh Finegold
449 Sherman Avenue
Palo Alto, Calif. 94304
Phone: (415) 326-2950
Incorporation date: 1/87
Major financial backers: Adler, Warburg Pincus Ventures, Xerox
Product: Computer-aided real-time design tools for software engineers
Date available: 9/87
Total equity invested: $9 million

Reliability Management Systems

Richard H. Howe
2 Eastwood Road
Windham, N.H. 03087
Phone: (603) 434-2635
Incorporation date: 1986
Major financial backers: Private individuals
Product: Computer software/reliability products for large computer operations
Date available: In 10 to 13 months
Total equity invested: $235,000

Saratoga Semiconductor Corp.

Edward H. Browder
10500 Ridgeview Court
Cupertino, Calif. 95014
Phone: (408) 864-0500
Incorporation date: 9/85
Major financial backers: Weiss Peck & Greer, Matrix Partners, Interwest
Product: High performance semiconductor products made with a BiCMOS process
Date available: 3/87
Total equity invested: $28.5 million

Sierra Semiconductor

James V. Diller
2075 North Capitol Avenue
San Jose, Calif. 95132
Phone: (408) 263-9300
Incorporation date: 1/84
Major financial backers: Arscott; Norton & Associates; Asset Management Associates; Associated Venture Investors; Bay Partners II; Berkeley International; Borg-Warner Electronics; Bryan & Edwards; Burr, Egan & Deleage; Churchill International; Indosuez Investment Management Services; Investors in Industry; Litton Industries Inc.; MIP Equity Fund; Mohr, Davidow Ventures; Sequoia Capital (main investor); Singapore Technology Corp. Pte. Ltd.; Sutter Hill Ventures; Technology Venture Investors-2; Tellabs Inc.; Venrock Associates
Product: CMOS custom and semicustom semiconductor products with complementary ASIC products
Date available: Now
Total equity invested: $44 million - equity; $13 million -debt; $20 million - lease

Silc Technologies

Ralph Linsalata
34 Third Avenue
Burlington, Mass. 01803
Phone: (617) 273-1144
Incorporation date: 2/86
Major financial backers: Adler & Co., Fairfield Venture Partners, Lawrence Associates
Product: Automated VLSI design software
Date available: 1988
Total equity invested: $5 million

Stellar Computer Inc.

J. William Poduska
95 Wells Avenue
Newton, Mass. 02159
Phone: (617) 964-1000
Incorporation date: 12/85
Major financial backers: Greylock Management, Hambrecht & Quist, J.H. Whitney
Product: Very high performance interactive graphics supercomputing workstations
Data available: NA
Total equity invested: $30 million

Supertek Computers

L.W. Mike Fung
2975 Bowers Ave., Suite 203
Santa Clara, Calif. 95051
Phone: (408) 727-5749
Incorporation date: 6/85
Major financial backers: Glenwood Management, Charter Venture Capital
Product: Minisupercomputers
Date available: End of 1988's first quarter
Total equity invested: $2.5 million; $2.8 million (second round)

Syntellect Inc.

S. Thomas Emerson
21200 N. Black Canyon Highway
Phoenix, Ariz. 85027 -
Phone: (602) 264-5900
Incorporation date: 11/84
Major financial backers: Welsh, Carson, Anderson & Stowe; Hambrecht

& Quist Venture Partners; DeMuth, Folger & Terhune; El Dorado Investments; SunVen Partners; Horsley Keogh Associates; Rainier Venture Partners; CIGNA Investments, Advanced Technology Development Fund; Michigan Capital & Service Inc.
Product: An artificial intelligence-based system for automated inquiry and data entry via touch-tone telephones that automates the functions performed by telephone/CRT operators
Date available: 5/86
Total equity invested: $11.8 million

Videotelecom Corp.

Lawrence Seligman
11002-B Metric Boulevard
Austin, Texas 78758
Phone: (512) 834-9734
Incorporation date: 6/85
Major financial backers: Robertson Colman Stephens
Product: Video teleconferencing systems
Date available: 10/86
Total equity invested: NA

Xilinx Inc.

Bernie Vonderschmitt
2069 Hamilton Avenue
San Jose, Calif. 95125
Phone: (408) 559-7778
Incorporation date: 3/84
Major financial backers: Hambrecht & Quist, Kleiner Perkins Caufield Byers, J.H. Whitney
Product: Programmable gate arrays
Date available: 11/85
Total equity invested: $18 million

The following companies were nominated by one of their venture capitalist backers but did not respond to our questionnaire for additional information before deadline:

Aegis Inc.

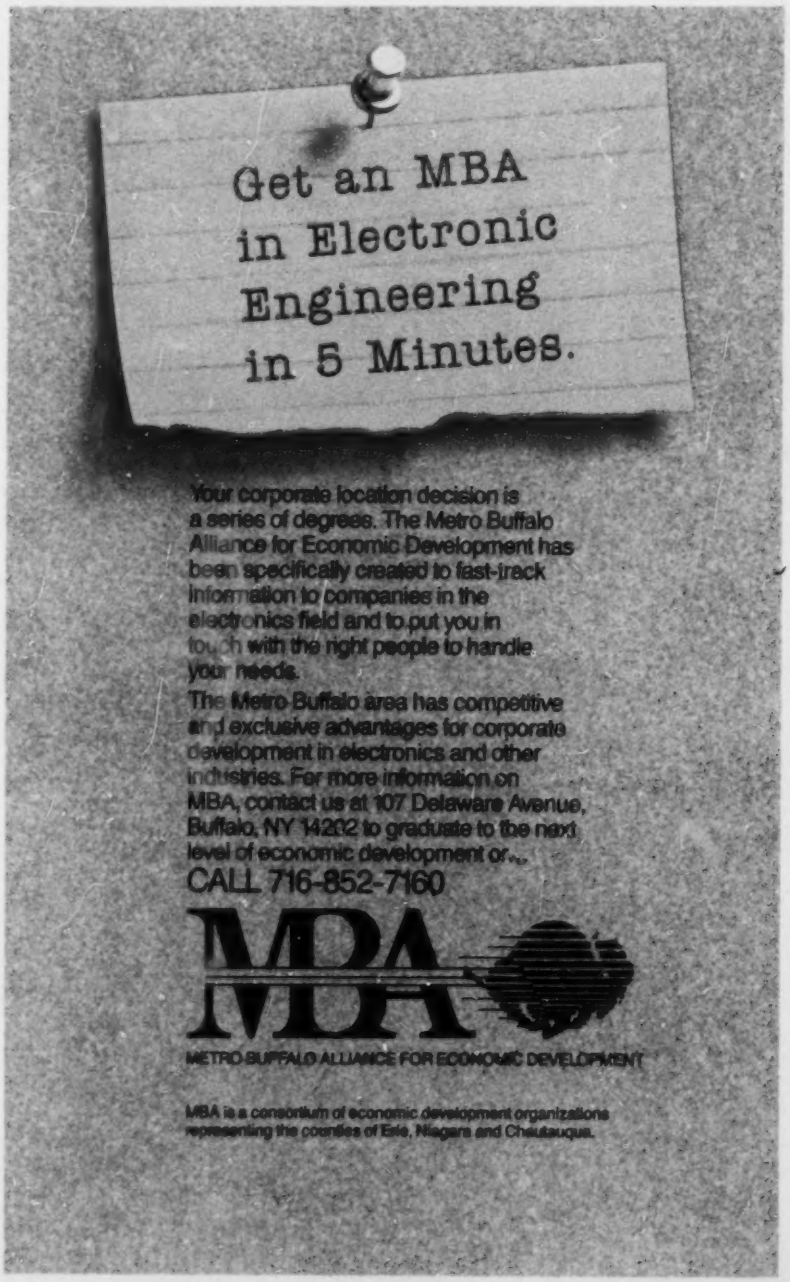
Jay Greenspan
South Welby Road
New Bedford, Mass. 02745
Phone: (617) 998-3141
Incorporation date: 4/84
Product: Packages for microelectronic circuits

Discorp

M. Albert
290 Easy Street, Suite 5
Simi Valley, Calif. 93065
Phone: (805) 584-0688
Incorporation date: 1/85
Product: Document imaging (high resolution) scanning, storage and retrieval using IBM PC AT and PS/2 as a platform

Integrated CMOS Systems

Lin Wu
440 Oakmead Parkway
Sunnyvale, Calif. 94086
Phone: (408) 735-1550
Product: Design and development of application-specific logical systems or subsystems using CMOS gate array technology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METRO BUFFALO ALLIANCE FOR ECONOMIC DEVELOPMENT
MBA is a consortium of economic development organizations representing the counties of Erie, Niagara and Chautauqua.

Integrated Silicon Systems Inc.

James P. Poitras
P.O. Box 13665
Research Triangle Park, N.C. 27709
Phone: (919) 361-5814
Incorporation date: 4/85
Product: ASIC design and CAE workstations

Intellicall Inc.

Stephen Polley
2155 Chenault, Suite 410
Carrollton, Texas 75006
Phone: (214) 416-0022
Incorporation date: 11/84
Product: Intelligent pay telephones

Karlin & Collins

Barry Karlin
740 East Arques Avenue
Sunnyvale, Calif. 94086
Phone: (408) 736-3700
Incorporation date: 8/85
Product: Electronic navigational aids

Licom Inc.

Robert McIntyre
400 Herndon Parkway, Suite 500
Herndon, Va. 22070
Phone: (703) 689-0500
Incorporation date: 1/84
Product: Fiber-optic communication equipment
Total equity invested: $20.75 million

Molecular Devices Corp.

Gary Steele
3180 Porter Drive
Palo Alto, Calif. 94303
Phone: (415) 493-0166
Incorporation date: 6/84
Product: Silicon-based biomedical instrumentation

Ultron Labs

Wayne Catlett
4423 Fortran Court
San Jose, Calif. 95134
Phone: (408) 945-8812
Incorporation date: 1985
Product: Cryptographic systems

Two publicly held companies, Digital Microwave Inc. and IMProCOM Inc., were also nominated by the venture capitalists that we surveyed, but were not included.

Digital Microwave Inc.

William E. Gibson
170 Orchard Way
San Jose, Calif. 95134
Phone: (408) 943-0777
Incorporation date: 1/84
Product: Short-haul digital microwave radios

IMProCOM Inc.

Fred M. Jenner
6101 Idlewild Road, Suite 326
Charlotte, N.C. 28212
Phone: (704) 535-6574
Incorporation date: 10/85
Product: Image-processing communications

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OSAKA, JAPAN SEPTEMBER 21-24, 1988	BIRMINGHAM, ENGLAND SEPTEMBER 27-29, 1988	BRIGHTON, ENGLAND OCTOBER 18-20, 1988	KUALA LUMPUR, MALAYSIA JULY 1989

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fax: (301) 657-3096

Executive summary

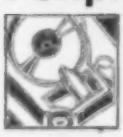
Economic overview PAGE 56

Will the recession hit in 1988, and if it does, in which quarter? The debate rages — despite a series of optimistic forecasts by a variety of market researchers.

Computers PAGE 60

Stable growth is the watchword for 1988. Dataquest projects sales of business computers systems will reach $21.3 billion this year, and the desktop departmental computer market will reach $3.6 billion.

Peripherals PAGE 66



Makers of everything from printers to disk drives find they must keep forcing prices down. 1988 will be no exception.

Semiconductors PAGE 68

The Semiconductor Industry Association remains optimistic about chip demand, despite fallout from "Black Monday." Sales are expected to soar 18% this year, officials claim.

Components PAGE 72

Worldwide demand for surface-mount (SM) capacitors will reach 48.6 billion units by 1990. Demand for SM resistors will reach 50.5 billion units during the same time frame, industry sources say.

CAD/CAM/CAE PAGE 76

If all goes well, U.S. vendors should ship $4.95 billion worth of computer-aided engineering, design and manufacturing systems this year, reports Daratech Inc.

Production equipment PAGE 80

Worldwide sales of semiconductor manufacturing equipment could grow 24% to $7.1 billion this year, according to VLSI Research Inc., as new technologies take hold.

Test & measurement PAGE 82

Prime Data Inc. predicts there will be steady growth in the T&M market in 1988, as worldwide sales hit $8.2 billion by year-end, up 13% over the previous year.

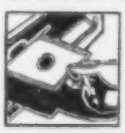
Communications PAGE 84

Developments in transmission equipment will drive the telecommunications market this year — a market that Dataquest says will exceed $203 billion by 1991.

Distribution PAGE 88

The $7 billion industrial distribution market is driven by end-user demand, and that's still a big question mark. But the National Electronic Distributors Association is forecasting 16% growth this year.

Software PAGE 92



Sales of all types of software — including systems, tools and applications — should jump nearly 23% this year, to $24.4 billion, according to Input.

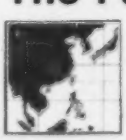
Electronic materials PAGE 95

After three years of flat pricing, silicon prices are strengthening — reflecting stronger demand in 1988, according to Rose Associates.

Europe PAGE 97

Despite recessionary fears, optimism abounds on the Continent, where Dataquest is projecting that European sales of 1Mb DRAMs will reach 20 million units this year.

The Far East PAGE 100



The four tigers — Hong Kong, Singapore, South Korea and Taiwan — today consume $2.9 billion in semiconductors. By 1992, consumption will reach $13 billion, according to Dataquest.

BY BARRY CUSICK

Electronics in '88: Growth, but no cigar

U.S. electronics firms expect upturn despite threats of recession. But wariness is the watchword: 1989 may be grim

Things looked so promising. All the indications were pointing to solid growth in 1988 in most sectors of the electronics industry, with some surprisingly lively upturns in segments like personal computers and — yes — even semiconductors. And as the order books fattened, few saw much reason to fret unduly over what appeared to be the U.S. government's problems alone: the large trade deficit and an alarmingly steep national debt.

But that was before Oct. 19, 1987 — the day the Dow Jones Industrial Average went into free-fall, losing altitude at a rate that not even the most prescient economist might have predicted. And suddenly, all those magazine articles and pop-pyschology books with alarmist titles like *The Great Crash of 1990* — the ones that most had written off as contrarian doom-mongering — had a nation full of riveted readers.

Electronics executives were among the most avid readers. Accustomed though they are to business cycles that make most fairground rides look tame, none was prepared for the Wall Street debacle, and everyone craved insight and guidance to help their forward planning.

Initially, it didn't look as if they were going to get it from any of the usual sources. Economy watchdogs like Analytics, a Palo Alto, California-based consultancy, cut their forecast for 1988 electronics-industry growth in half, from 8% to 4%. Other forecasters held off, pending more news from the financial leaders. And everyone wondered whether the big recession was finally on its way. "If the financial markets affect the economy in the worst way, then all bets are off," says James Burns, president of chip maker Burr-Brown Corp.

Monetary meltdown

The monetary meltdown caused major consternation at one important conference on the semiconductor industry: top-level management like Intel Corp.'s chairman Gordon Moore cut short presentations as they rushed off to become involved in a little crisis management.

The electronics industry will grow at a real 7.2% rate in 1988, while the real GNP overall will grow 5%

The stock shock showed up in other ways, too. For one maker of rigid disks for disk drives, Disk Technology Corp., it was the final straw that poked it into Chapter 11 proceedings after its secondary stock offering failed. And semiconductor production equipment maker GCA Corp. postponed a $22 million equity offering because of the diving Dow. Says Kent Webb, founder of Analytics: "[Shakiness on Wall Street] makes it harder to raise capital through the equity market. It's shaken the confidence of consumers and business people and raised the fundamental problems of the national and the trade deficit."

But by mid-November, some semblance of normalcy was returning, albeit in an environment in which the Dow Jones indicator was running more than 20% lower than its August peak and where the dollar had slid down further than it had previously for many a year. And a degree of optimism had begun to creep back into the conversations of electronics executives. "It's very unclear what impact, if any, these two days [Oct. 19 and 20] will have on calendar 1988. If capital spending is approximately what was forecast, everything will be OK," said August Klein, president of computer maker Masscomp Corp.

Others remained positively upbeat: "I don't see any fundamentals that suggest that 1988 won't be a good year," declared Michael Hackworth, chief executive of chip maker Cirrus Logic Inc. And at the Comdex computer show in Las Vegas in early November, despondency was a much scarcer commodity than buoyancy over the personal computer renaissance.

And those who study the economic tea leaves had begun sounding more cheerful. According to Kenneth McGill, a senior economist with Philadelphia-based Wharton Economic Forecast Associates (WEFA), the electronics industry will grow at a real 7.2% rate in 1988, while the real gross national product (GNP) overall will grow 5%. "The electronics industry is growing one and a half times faster than the rest of the economy. In 1986, electronics comprised 15% of total U.S. manufacturing. In 1988, it should be 16.3% and by

1991, 17.2%," reports McGill.

By mid-November, the appearance of improved trade figures for September had put most observers into a more relaxed frame of mind. As the dust settles, the word from one research firm that polls a broad cross-section of economists — the Arizona-based Blue Chip Economic Indicators — is probably as valid now as it was when it was written nine days before Wall Street's embarrassment: "The consensus says next year will not be an economic paradise — nor will it be an economic hell. It suggests special caution for 1989 and/or 1990. Maybe a recession [and a short one at that] but it won't be the beginning of a depression!" says the report.

Optimism for electronics

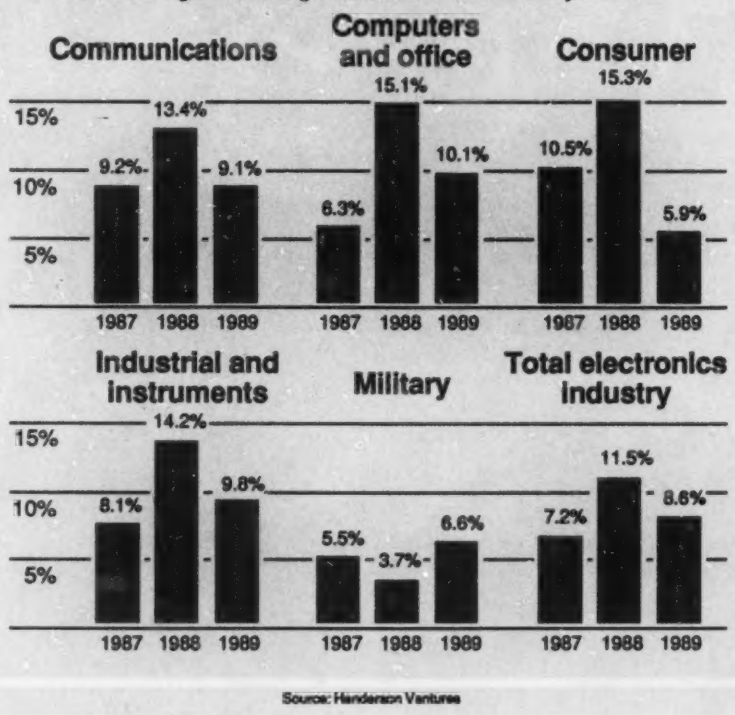
WEFA's McGill cites several factors behind his optimism for electronics, including technological advances, low OEM material and supply inventories, increased long-term equipment investment, a weaker dollar and an improving trade balance. He makes one long-range caveat, however: "The growth in the electronics industry over the next 10 years will be slower than the last 10."

Another forecaster, Data Resources Inc. (DRI) of Lexington, Mass., predicts that investment in electronics will be up across the board in 1988. DRI forecasts that capital investment in office computers and office machines will increase from 1.4% growth in 1987 to 11.4% in '88; investment in electronic computers and accessories will rise from 2.9% to 8.0%; and investment in radio, TV and communication equipment will jump from no growth in '87 to a 7.6% rise this year.

DRI expects the semiconductor market to grow 9.1%, compared to 6.3% in '87. "The industry broke out of its slump in the second quarter of 1987," said senior economist Richard DeKaser. "There's always a lag between computer manufacturing and computer component production."

The low point for the coming year appears to be in the military and aerospace sector. Virtually every analyst agrees that the military will be the weakest sector in electronics in 1988. The military budget, growing at a record peace-time rate under Ronald Reagan, is now being reduced. "Government spending went at a very fast pace in the last five years and things are tapering down," said Ralph Anavy, president of San Francisco researchers Electronic Outlook Corp.

This year should show some recession-beating growth in most electronics segments — but 1989 will wipe the smiles off executives' faces



Source: Henderson Ventures

Analytics' Webb says computer and office machines will make the largest gains. "The unveiling of IBM's new personal computer system has reduced much of the technological uncertainty that dampened the PC market in the recent past," Webb says. "PC demand should receive an additional boost from the replacement market now that the first wave of machines installed in 1983 and 1984 are reaching the end of their useful life."

Edward Henderson, president of Henderson Ventures of Los Altos, Calif., predicts consumer electronics will top the growth market, at a real 9.0%. Henderson thinks the consumer market will be most affected by fluctuating exchange rates. Electronic Outlook's Anavy predicts that the consumer market will be strong next year, mainly because personal disposable income is up.

For all this resilient optimism, however, there remain many nagging worries about where the U.S. economy really is headed. Issues such as the trade imbalance loom large, and the bullish conviction that consumers and capital-equipment buyers will not rein in spending remains untested. For consumer markets, the Christmas merchandising melee will be a crucial gauge. For capital-equipment sectors, the start of new fiscal years will prove interesting.

Crimped capital spending

Indeed, there is evidence to suggest that electronics industry capital spending *will* be crimped: Kenneth Olsen, president of Digital Equipment Corp., recently indicated that DEC was digging in for a possible recession by slowing down hiring and capital spending. Many other electronics companies may use the influential computer giant's actions as their yardsticks, too.

Many take comfort in an apparent silver lining to Wall Street's October cloud: that the stock shock at least awakened the Reagan administration to the severity of the trade and national deficits. The federal government has set its sights on a $23 billion

cut in the national deficit for fiscal 1988, a target many economists argue is not high enough. Meanwhile, the Congress is stepping up efforts to thrash out a more conservative budget. Whipping senators and representatives along is the automatic budget-cutting mechanism that will make indiscrimate across-the-board cuts: the Gramm-Rudman-Hollings law, which was due to go into effect Nov. 20.

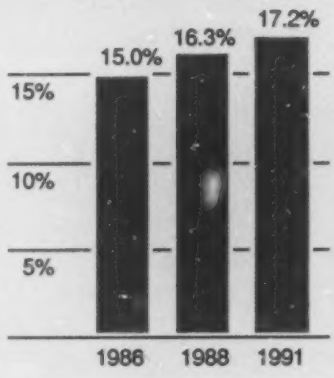
Readings on the health of the general economy remain mixed. Analytics, for instance, predicts 3.4% real GNP growth this year, compared to WEFA's estimate of 5.0%. The average of 51 analysts polled by Blue Chip Economic Indicators calls for real growth of just 2.8%. Some venture capitalists at least hold out hope: Claims Kipling Hagopian, general partner at Brentwood Associates in Los Angeles: "It will be a good year in industry in general because the economy is still strong."

Much depends on how quickly the trade deficit erodes. Henderson says that an improving export rate will create "the economy's longest peacetime expansion on record, into 1989, but we will slide into a recession at the end of 1989." Just as deterioration in August's trade balance pushed panic buttons all over Wall Street in October, the report on September's improved figures — a $1.6 billion drop to $14.1 billion — sent the Dow Jones soaring again. "The real merchandise trade balance will be [a negative] $131.6 billion in 1988, as opposed to $158.6 billion in 1987. It's definitely getting better," says WEFA's McGill.

"Although the situation is far from certain," Henderson says, "it is likely that the trade deficit will not deteriorate further during the next two years, and will probably improve significantly. In real dollars, the trade rate has improved three quarters in a row."

Real dollars are a real issue. Early-1987 declines in the greenback's value appeared, to the surprise of many, to do virtually nothing to boost U.S. exports and stem the tide of imports. But the improving trade balance may be the evidence that economists have been waiting for. Additionally, November's dramatic drop in the value of the dollar may at last jerk imports back into line as overseas business, which until now has been absorbing the higher cost of selling into the United States, is forced to increase prices to maintain some semblance of profits.

Electronics is growing 50% faster than the rest of the economy, increasing as a percentage of America's manufacturing output



Source: Wharton Economic Forecast Associates

Henderson predicts that a weaker dollar will help U.S. exporters soon. "There is usually an 18- to 24-month lag between the decline in the value of a currency on international markets and the start of a trade recovery," he says.

Trade retaliation

However, there is rising concern that Congress, impatient with the bloated trade imbalance, may force through tariffs on imports, a prospect that could easily invite retaliation and alienate the very overseas markets that the United States needs to nurture if its exports are to grow.

A side effect of the dollar's devaluation is that more foreign companies are setting up manufacturing facilities on U.S. soil. Henderson Ventures' Henderson believes the influx of Japanese electronics manufacturers to the United States will continue. "The new rules of the game are that you manufacture where you market," he says.

A related area of uncertainty is the future of America's relationship with Japan. Japan's financial sector has underwritten much of the U.S. expansion, pushing America's debt to Japan to alarming levels. And word is surfacing that consequently, those Far East investors worry over whether America will become "Japan's Brazil." Changing the relationship may involve radical compromises in the future, compelling Japan, for example, to import more from the United States; or to play a wider role in global defense, and forcing the United States to become more of a team player on the economic field.

It also means that America's economic pundits will be watching the way that Japan's new prime minister, Noboru Takeshita, starts to run the country. Which, in turn, raises the question of what effect the new U.S. leader will have when elected this November. Traditionally, the economy gets a pick-me-up in the months prior to the presidential elections, but whether this is enough to stop any economic downdraft, few can say.

However, none of this implies that U.S. electronics executives can put the onus entirely on the federal government. Electronics Outlook's Anavy says that U.S. corporations "need to take a long-term approach which will cost them in the short run, and develop lean volume-production techniques" in order to compete in the global electronics market. "High-tech trade deficits need more than just exchange rate adjustments to be rectified," he says.

Interest rate fluctuation — a traditional worrier — is currently taking a back seat to obsession with the vicissitudes of the Dow. Prior to Wall Street's crash, interest rates were inching northward, a direction that was sharply reversed by the Federal Reserve in response to the stock market disaster and further lubricated by the dollar's slide. New lower rates should ease capital-spending constraints.

One universal belief among experts is that electronics will continue to outperform the economy for the forseeable future. WEFA's figures show the industry created 15% of all manufactured goods in 1986, while its employees made up only 2.5% of the workforce, says Harry Lowenstein, manager of industry statistics for the American Electronics Association of Palo Alto, Calif.

If there is any lesson in the traumatic financial events of late 1987, it is that electronics managers need to prepare better than ever before, by pursuing economic and market outlooks in more detail than ever and by devising worst-case plans that can be implemented at short notice. Given the vagaries of economic life in the late 1980s — and given that 1989 may show sharp slowdown — this is basic survival strategy. □

BY ANNE KNOWLES

Computers: Stable growth is the watchword for 1988

Many manufacturers are sure computer buying will continue. Watch high- and low-end systems markets for the best action

Despite economic uncertainties, many computer manufacturers are fairly optimistic about the year ahead. Although few company executives are game to predict the economy's immediate future, most appear confident that the hardware industry is protected from all but the worst economic disasters.

"If there is a moderate downturn, we are relatively well insulated because people spend money on products to improve productivity," says Jack Lewis, Amdahl Corp.'s chief executive officer. "Demand for our products is very strong and we don't see any change."

Gilbert P. Williamson, executive vice president of NCR Corp., agrees. "We don't see any big warning signs," he says, speaking of a slowdown. "To date, there has been no overt activity by our customers," to curb computer buying, adds Williamson. Instead, the NCR executive believes computer spending will be maintained because users purchase systems to improve efficiency, especially in times of trouble. Says Williamson: "That augurs well for the future, even in view of uncertainties."

Apparently, many industry watchers concur. Revenue for business computer systems, excluding personal computers, is expected to rise 7%, from $19.9 billion in 1987, to $21.3 billion this year, according to Dataquest Inc., a market research firm in San Jose. The highest growth area should be what Dataquest defines as small departmental computers, priced between $25,000 and $75,000. Dataquest estimates that sales of such systems should increase 9%, to $3.6 billion in 1988.

Double-digit growth

Personal computer sales will post double-digit growth, according to Peter Teige, an industry analyst with Dataquest. The worldwide market for microcomputers should jump 10.5% in 1988, to $38.9 billion. Shipments for the year will increase to 18.9 million units, up from 17.1 million personal computers shipped in 1987.

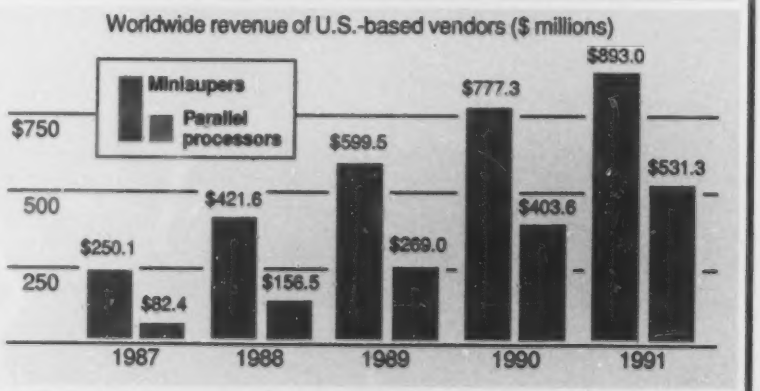
Spurring that momentum will be IBM's projected sales of its new PS/2 models, which incorporate Intel Corp.'s 32-bit microprocessor, the 80386. IBM started shipping the high end of the PS/2 line, the Model 80, in volume this past October. And Big Blue was expecting to set records during that last quarter alone. "IBM is claiming it is going to ship as many 386-based systems as anyone else has all year," says Dataquest's Teige. Teige believes the onslaught of 386-based products — such as IBM's PS/2 models and Compaq Corp.'s Deskpro 386 — will continue this year, pushing sales of such systems to one million units.

The barrage of PS/2 clones may begin in 1988 also. Teige says there is wide-ranging speculation on whether other manufacturers can copy the IBM systems, without catching the wrath of IBM, by the end of this year. Many analysts believe the third party clones won't start parading until 1989. In any case, says Teige, "they may be off the market as soon as they hit the market, if IBM decides to litigate." And taking PS/2-compatible makers to court for copyright violation may be easier to accomplish than expected. Says Teige: "IBM thinks it will be difficult to duplicate the firmware. IBM has ways to test compatible PS/2 machines to see whether clones violate copyrights. They can be easily tested and evidence can be easily obtained."

But the delivery of OS/2 will be the most significant microcomputer event this year. Microsoft Corp.'s operating system designed for the PS/2 line of computers was scheduled to ship to customers last December. IBM should deliver its proprietary graphics interface for the system, called the Presentation Manager, sometime later. By the end of the year, says Teige, IBM should ship its proprietary version of the operating system, called the Extended Version, which has an embedded database management system. A surge of third party application packages written for the new operating system will appear by year-end also.

Apple Computer Inc. hopes to maintain its apparent success selling systems to corporate accounts. Dataquest's Teige thinks Apple will an-

Parallel-processor computers are expected to win greater acceptance in commercial applications



Source: International Data Corp.

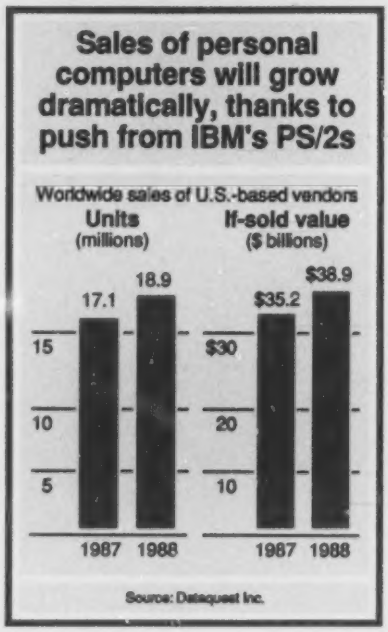
nounce both new additions to its family of microcomputers, and the first round of price reductions on its current models, the Macintosh II and the Macintosh SE.

At the other end of the computing spectrum, the competition is heating up. The supercomputer market has an unprecedented number of players and the premier position held by Cray Research Inc. is being challenged by both domestic manufacturers and Japanese players. In the United States, there are start-ups like CHoPP Computer Corp., which expects to deliver its first supercomputer in late 1988, and Saxpy Computer Corp. In addition, ace designer Steven Chen left Cray last year to found SuperComputer Systems in Eau Claire, Wis. And ETA Systems last year announced a $20 million sale of its eight-processor Model E supercomputer to the Tokyo Institute of Technology.

Japan's market has been difficult for American manufacturers to crack, and it represents up to 40% of the worldwide supercomputer market, says Vicki Brown, an industry analyst at International Data Corp., in Framingham, Mass. The worldwide high performance hardware market, which includes supercomputers, minisupercomputers, parallel processors and high performance mainframes, will hit $2.2 billion this year, up from $1.5 billion last year, according to IDC. The supercomputer segment, says Brown, was $703.8 million last year and is growing 20%, compounded annually.

Lloyd M. Thorndyke, president and chief executive officer of ETA Systems, says the company was able to sell in Japan because the buyer required a system based on multiple processors. To date, the three Japanese supercomputer suppliers — Fujitsu, Hitachi and NEC — do not offer multiprocessor systems. But Thorndyke believes that will soon change. He says that in 1988, "all supercomputer companies will announce some configuration of a multiprocessor system." When ETA's multiprocessor machine won the bid at the Tokyo Institute of Technology, says Thorndyke, "the message got through to the Japanese companies. And they learn fast."

IDC's Brown expects the hottest sales growth to occur in parallel processors. In 1987, sales of multiprocessor-based computers used as parallel processors reached $82.4 million. Brown anticipates that figure will jump to $156.5 million this year and continue to grow 66.8%, compounded annually, over the next five years.



IDC's Brown also thinks parallel processors — which divide pieces of a program among multiple processors — will continue to gain acceptance in commercial applications. For example, BBN Advanced Computers Inc., a subsidiary of Bolt Beranek and Newman Inc., in Cambridge, Mass., announced its RT1000 Butterfly parallel processor, which will incorporate a real-time operating system developed by MTS Systems Corp., for manufacturing applications. Thinking Machines Inc., also in Cambridge, has sold its Connection Machine — using 64,000 processors — to such commercial users as Dow Jones Information Services, for on-line database services, and United Technologies, for computational chemistry.

The supercomputer segment was $703.8 million last year and is growing 20% annually

"A trend in the minisupercomputer market will be the progressive use of these machines outside R&D and into heartland America," says Robert Hesser, vice president for marketing at Cydrome Inc., a minisuper maker in Milpitas, Calif. Frank Vince, vice president for marketing at Convex Computer Corp., a minisuper manufacturer in Richardson, Texas, agrees. "Early innovators have been the universities. We affectionately call them the lunatic fringe," says Vince. "Now we are making inroads into industrial America."

While sales of minisupers should jump to $421.6 million in 1988, up 68.5% from last year, the competition is starting to close in. Last year, ETA Systems announced its ETA10-P, which sells for less than $1 million and is much closer in price to the minisupers than Cray Research's $2 million supercomputer. And Digital Equipment Corp., says IDC's Brown, should announce a vector processing add-on to its VAX series of superminicomputers this year. There has been much speculation about whether DEC would enter the minisuper market with a standalone system of its own, but Brown believes the company would rather provide an attached processor for those customers needing it.

Big Blue maneuvers

Brown also believes IBM, which currently has a vector add-on for its 3090 mainframes, called VF for vector facility, will migrate a similar attachment downward into the 4300 mainframe area and into its new midrange 9370 arena. Furthermore, the current players in the minisuper market, says Brown, will continue to slash prices on existing systems and announce lower-priced machines such as Alliant Computer Systems Corp.'s $99,000 FX4, introduced in late 1987.

Regardless of the economic outlook, many executives feel that advances in technology will continue. "Looking forward, we don't see any major change, from the technology point of view," says NCR's Williamson. "There will be new price performance improvements brought about by technology like VLSI [very large scale integration]," says Williamson.

And improvements will come from advances in software. "There will be development done more in software over the next few years," in the high performance computer market, says IDC's Brown. And customers will place more importance on software, says Peter Appleton-Jones, president of minisuper maker Elxsi Ltd., in San Jose. "Software has become the standard customers are concerned with," says Appleton-Jones. "The [hardware] equipment is less important. □

BY VALERIE RICE

Peripherals: The plague of plummeting prices

Makers of everything from printers to disk drives find they must keep forcing prices down. 1988 will be no exception

Moderate prosperity seems to be the theme for 1988 in the peripherals industry. Although some segments of the market are better than others (disk drives are more profitable than printers, for example), most major segments are showing at least marginal growth, and industry executives are, on the whole, bullish on 1988. However, one problem continues to plague the peripherals industry: falling prices. "Every year it's the same," says John Boldt, associate director of the printer industry service at San Jose market research firm Dataquest Inc. "Performance and functionality go up and prices go down."

Prices are dropping substantially every year, and 1988 will be no exception. For example, disk drive prices drop an average of 25% to 40% per year, according to industry executives; and printers, terminals and add-in card prices also drop correspondingly.

But the industry is growing, even if revenue is not keeping pace with unit sales. Numbers from the two largest segments of the peripherals industry — printers and disk drives — substantiate this. Disk drive revenue will increase 15% over 1987, in 1988, according to Mountain View, California-based Disk/Trend Inc., while unit sales will increase 33% in 1988. Printer shipments in 1987 are likely to reach 5.3 million units, growing to 5.9 million units in 1988, according to Dataquest. Printer revenue will increase from $6.6 billion in 1987 to $7.0 billion in 1988.

Powering this growth are two of the biggest names in the personal computer industry: IBM and Apple Computer Inc. Their product introductions in 1987 — the Personal System/2 and the Macintosh II and SE, respectively — opened up new markets for peripherals, particularly in the areas of add-in cards, extra storage and enhanced monitors.

Yet 1988 is not so far removed from the tough times of 1985 and 1986, and vendors are worried about market shakeouts, particularly in the very crowded disk drive, printer and add-in board businesses. And no one is willing to predict the long-term impact of stock market fluctuations early last fall. What companies can and do address, however, is market overcrowding.

"There are an awful lot of companies out in the market right now," says Giacomo Versecci, marketing manager for Honeywell Bull Italia's worldwide printer operation. "It is hard to stand out in the crowd."

Vicious business

Disk/Trend's Robert Katzive notes that the disk drive industry is "fairly crowded. It's surprising how many companies are taking a shot at the market. There are 42 OEMs [original equipment manufacturers] of 380-megabyte drives, and a half dozen or more of 760MB drives. Not everybody can win. In fact, there are going to be very few winners." Even board maker Paradise Systems Inc. president Thomas Van Overbeck admits that "it's vicious out there."

Some industry executives are predicting that a consolidation will begin in 1988, prompted by pricing pressure. But others, noting the phenomenal success of start-up disk drive maker Conner Peripherals in 1987, feel that there may still be room for small aggressive companies with good ideas.

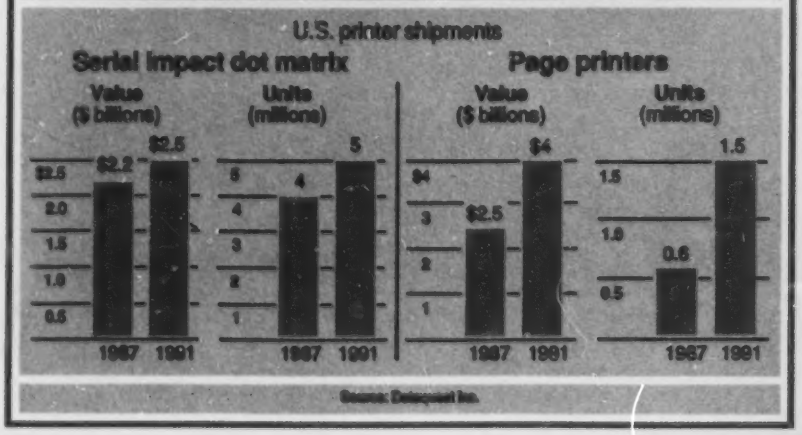
The terminals business — one of the older businesses in the peripherals sector — is probably the most settled to date. If there was a shakeout, it has come and gone, leaving three large companies, Ampex, TeleVideo Systems Inc. and Wyse Technology, and several small companies with the run of the market.

"There is going to be consolidation into 1988," says Ampex's John Murray, "but it is pretty clear who the leaders in the market are."

The terminals market is estimated to be a $5 billion retail market, of which about 60% is in the United States. Offshore manufacturing and pressure from both distributors and smaller players have caused "severe price erosion," Murray says, but he feels confident that 1988 will be a good year for the major companies

"In 1988 we will see strong pressure to keep the price steady and even more pressure on performance. This is a growth marketplace," he con-

Making money in the printer business is no picnic these days. Page printers offer the consolation of strong growth



tends. "Terminals are now approaching the low end of computers. They have more remote processing power."

One of the most volatile and crowded segments of the peripherals industry, the disk drive market has a sort of uncanny attraction for many players looking for volume business and high average selling prices. For those in the high end of the market, 1988 promises to be a growth year. In the low end, however, the competition and price erosion remain fierce.

Says Robert Oakely, marketing director of Microscience International Inc., "10MB disk drives are being given away, liquidated below the manufacturer's cost. Twenty megabit drives are not as profitable as they used to be, either."

Yet despite the lack of money to be made in the low end, the vast bulk of units shipped are in the sub-100MB range, according to Disk/Trend's Katzive. "Of the 17 million units expected to be shipped in 1988, 15 million of them are small diameter and under 100MB," he says.

In the low end of the market, Seagate is the biggest OEM company, Katzive says, noting that they might ship up to 3 million drives in 1987. However, he hastens to point out that, "they're not making as much money as they used to."

Where's the grim reaper?

But for the higher density manufacturers, "There is not a big grim reaper out there," Oakley says. "At worst, the disk industry will be in the growth mode. At best, we will see a tremendous percentage increase in 1988."

The bulk of the high-density drive business remains in the 5.25-inch format, although the newer 3.5-inch and the half-height formats are doing well also. Even 8-inch drives have their place, says Control Data Corp.'s marketing manager James Oughresby. He says that CDC continues to do a strong business in the larger drives, and expects that to continue through the early 1990s. CDC has also moved strongly into the 3.5-inch market, and Oughresby claims to have the highest capacity 3.5-inch drive on the market to date.

Disk drive revenue will increase 15% over 1987 this year, while unit sales will increase 33%

Capacity battles will continue to be an issue in the coming years, Katzive contends. One reason is that users can never seem to get enough memory. Workstation vendor Sun Microsystems Inc., for example, says it can never offer its customers too much storage, so it is constantly on the prowl for more density, not to mention good reliability and speed.

Drive maker Maxtor Inc. has placed its reputation firmly behind the very high-capacity and high-speed drives, says marketing vice president Robert Teal. The bulk of Maxtor's business through 1988 will continue to be 5.25-inch drives, but the densities should increase dramatically. "Our 190MB product is our cash cow currently," Teal says, "but the 380MB drive is in strong demand. Our 760MB drive may have the shortest product integration time of any product we have ever seen. Customers are accepting that product and integrating it instantly."

It's pretty tough to make money in the printer business right now. "Companies used to try to beat their competitors on price and performance," Dataquest's Boldt says. "Now that is going away. You can't beat them hands down. You just want to stay even."

Distribution is such a sensitive issue in printers that companies will sometimes sell products at a loss just to keep distribution channels available. Boldt says that he has seen price adjustments as little as $10, all done in an effort to stay even with the competition.

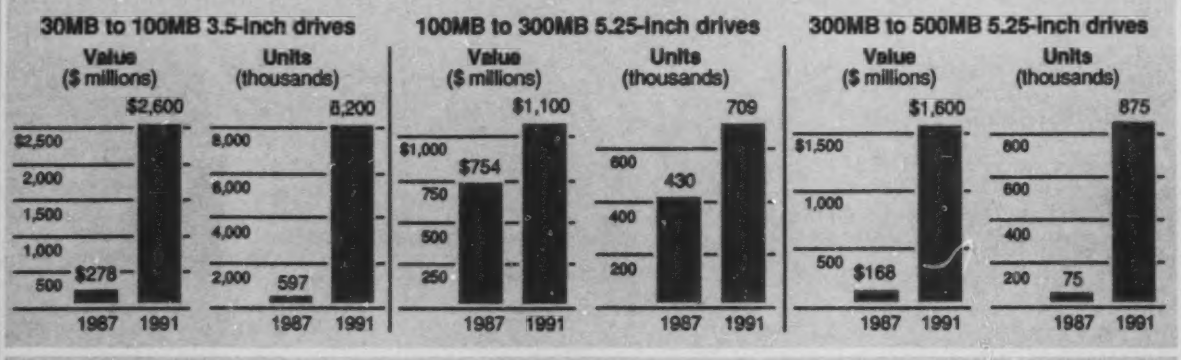
At Honeywell Bull, marketing manager Versecci says that his only strategy for survival worldwide is differentiation through higher functionality and better performance than other companies. One of the difficulties in printers, though, is not only the large number of players, but the large number of warring technologies.

Support for color

Honeywell Bull has decided to support color line printers, Versecci says, and the color is not an option. He says that if he were to wait for users to ask for color, he might wait for-

Makers of high-performance hard disk drives are scrambling to catch up with demand

U.S. high capacity disk drive shipments



Source: Disk/Trend Inc.

ever, and this way they will get used to color without having to pay a premium for it.

The largest-selling printer to date is Apple Computer Inc.'s ImageWriter, Boldt says, and it will likely continue in that role through 1988. Page printers, which are mostly laser printers, will account for 600,000 of all the printers shipped during 1987, a figure which is double that of 1986, according to Boldt. 1988 will continue to see growth in page printers, although probably not at the doubling rate of previous years.

Add-in boards are a great business to be in if the market is video, contends Paradise's Van Overbeck. Otherwise, it could be a difficult year. The reason is that IBM's Personal System/2, while spurring on sales in some areas, has cut off sales completely in others.

With so much functionality now included on the motherboard, there is very little room —or need — for add-in cards in traditional areas like enhanced speed, math coprocessors, and so forth.

Video is one good area for the IBM compatible market, Van Overbeck says, because users wanting to upgrade XTs or ATs to PS/2-like functionality only have to add a monitor, a 3.5-inch drive and a Video Graphics Adapter (VGA) card to have PS/2 functionality for much less money. That is where Paradise is hoping to position itself for the future.

"This marketplace continues to be exciting," Van Overbeck says. "If a major corporation is switching to PS/2s, what do you do with all the XTs and ATs? We think the market for video boards is really a VGA market."

"There are 20 million machines installed," he continues. "Say 5% are going to be compatible with the PS/2. That's 1 million boards. That's a big number."

For the add-in board business as a whole, competition and pricing pressure will soon start to drive companies out of the business, Van Overbeck believes. "We are becoming what systems integrators were. The people who will survive are vertically integrated. I don't think that by integrating someone else's chips a company can compete.

1988 will likely witness the add-in board industry's continued efforts to move more toward upgrade products for the installed systems base, rather than toward designed-in parts of a new system. □

BY ALDEN M. HAYASHI

Semiconductors: A dicey year ahead as growth cools

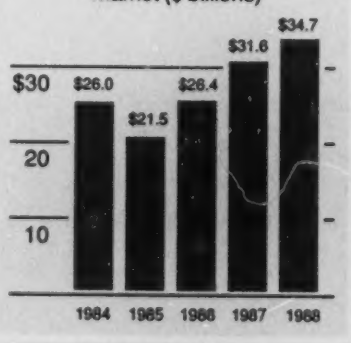
Wall Street's crash has made the chip industry nervous. So far it's business as usual, but for how much longer?

The mood was definitely upbeat at the annual dinner meeting of the Semiconductor Industry Association (SIA) last Oct. 1. After being battered by the calamitous recession of 1985-86, the bigwigs of the U.S. chip industry finally had reason for celebration. According to the market figures presented that night, worldwide semiconductor sales would end up soaring 21.8% in 1987 and 17.9% in 1988.

"Today is the day that we are officially declaring that Silicon Valley and the worldwide semiconductor industry is in the midst of a sustainable economic upturn," said Wilfred J. Corrigan, chairman of the board of LSI Logic Corp. of Milpitas, Calif. "At the same time, we are closing the books on one of the most painful downturns in our industry."

Forget those outrageous growth projections: The Wall Street crash will help chip sales to slacken off

Worldwide semiconductor market ($ billions)



Source: In-Stat Inc.

Later that month, the celebration continued at an industry conference held in Phoenix, Ariz., by Dataquest Inc., a market research firm headquartered in San Jose. At the annual gathering, Gene Norrett, vice president and director of Dataquest's Semiconductor Industry Group, managed to outdo the often overly optimistic SIA numbers by boldly forecasting a growth of 24% for 1988.

Then, on October 19, the stock market crashed.

"We are definitely less optimistic now and we are considering a change in our numbers," says Joseph K. Borgia, Dataquest semiconductor analyst. Borgia says that Dataquest's revised number will probably be around 15%. Other market researchers are predicting even lower growth. Integrated Circuit Engineering Corp. (ICE) and In-Stat Inc., both headquartered in Scottsdale, Ariz., are forecasting growth in the 10% range, respectable but much lower than the 20% surge of last year when worldwide semiconductor sales topped $31 billion, according to In-Stat. Interestingly enough, ICE was forecasting its cautious 10% figure months before the October stock market plunge. "We always felt that the steam of '87 would take away from the punch of '88," says William J. McClean, ICE research analyst.

Actually, the U.S. market should hold up better than other international markets, claims In-Stat's Beedle. He predicts that U.S. semiconductor sales will grow by 11.1% this year, down from 18.8% last year. During the same time period, the market in Japan will slow to a 8.4% growth, down from 15.5%, while the European market will slump at 5.5%, compared with 13.0% last year. The greatest slowdown, however, will occur in the ROW (rest of world) countries where market growth will plummet from a scorching 64.2% rate last

year to 20.1% this year, according to In-Stat's figures.

The trickle-down scenario

What semiconductor industry executives fear most is that Wall Street's recent conniptions will rattle consumer confidence leading to an overall economic recession, particularly in the United States. If that happens, businesses will be buying less computers, telecommunications gear and other electronics products and, consequently, the market for chips used in those products would plunge.

Although this trickle-down scenario has chilling implications, clearly no one in the industry is panicking. "Trying to guess what's going to happen, given the recent events on Wall Street, really just doesn't serve any purpose. Overall, we're still in good shape and on track for the medium to long term," asserts Kevin McGarity, vice president in charge of North America sales and marketing for the semiconductor group of Texas Instruments Inc., headquartered in Dallas.

"We're not changing any of our plans," asserts James A. Norling, executive vice president and general manager for the semiconductor products division of Motorola Inc. of Schaumburg, Ill. Indeed, Norling asserts that Motorola will proceed as planned with the building of a new factory later this year in Japan, per the company's joint venture with Toshiba Corp. of Tokyo.

Intel Corp. of Santa Clara also remains confident. According to Andrew S. Grove, chief executive, Intel will invest around $400 million in capital expenditures this year, up from $300 million last year and less than $200 million the year before. Still, Grove says, "The stock market has made us nervous and we are going to scrutinize our own business more carefully from now. Adds Motorola's Norling, "We're watching carefully and keeping our eyes on the horizon."

So far though, none of the chip vendors has complained about any sales slowdown. "Ordering levels have remained high," asserts Dataquest's Borgia. He explains that chip customers have continued to do well and have consequently continued to buy massive quantities of chips, so far at least.

In particular, the computer market is forecast to grow. "Our business is up substantially," says Hugh J. Lynch, a vice president in the Development and Production Division of NCR Corp., headquartered in Dayton, Ohio. "We've had seven consecutive quarters of double digit order growth," boasts Lynch, "And based on the computer demand we've been experiencing, we see a pretty strong seminconductor market out there." Last November, IBM chairman John F. Akers was also optimistic. In an address to securities analysts, he said that IBM had not experienced any downturn in orders since the stock market's collapse.

U.S. semiconductor sales should hold up better than in Japan and Europe. But ROW will slump

Telecommunications customers are also confident. The communications market should grow too. John S. Buchan, a vice president for Northern Telecom Inc. in Nashville, Tenn., says that he expects his company to buy about twice as many Motorola chips this year as it did last year. Although he says that half of the increase will be due to buying more Motorola chips in lieu of other chip companies' products, the other half will be due to a real increase in his company's semiconductor needs.

Consequently, TI's McGarity says, "We're still very confident . . . in the basic strength of the electronics industry." Nonetheless, pessimists predict that an overall economic recession is imminent, if not later this year, than surely in 1989. "The stock market is probably a precursor to other things," warns Jack Beedle, In-Stat president. Other market watchers assert that the first two quarters of this year will probably tell the story. "If the first half of the year is weak, then we'll really be in trouble because there just doesn't seem to be anything that would drive semiconductor growth in the second half," says Dataquest's Borgia.

Hamstrung expansion plans

A more direct effect of the stock market crash is that it might hamstring some companies' capital expansion plans. But luckily for most companies, the boom market last year allowed them to build up substantial cash reserves. "The stock market change *could* have been relevant to our ability to afford to make investments, but fortunately we have built up a $700 million cash position so we have no need for further cash infusions for the foreseeable future," says Intel's Grove. "We will be able to fund our pretty heavy investment program without being dependent on the capital market."

Indeed, Intel is fortunate. The company is on a roll as it tries to meet the soaring demand for its latest 80386 chips, the state-of-the-art 32-bit microprocessors. "We are running close to 100% of what our equipped facilities can produce," says Grove. Other companies are also bustling. "Most of our product lines are in allocation, or close to being in allocation," says James Townsend, strategic marketing manager for Toshiba America Inc. in Tustin, Calif.

But some of the smaller U.S. chip companies might be vulnerable to Wall Street's gyrations. Altera had scheduled an initial public offering last November but decided to scrub its plans after the October crash. "There's no sense in trying to go out there in this environment," says Rodney Smith, Altera president. "But," maintains Smith, "the good news is we didn't have to go public. We've got a strong balance sheet. We've got over $10 million in cash . . . so the stock market has not affected our operations at all. We'll just continue running our business as usual."

And that's the advice that most industry gurus are giving. What happened on Wall Street recently, says In-Stat's Beedle, "is something that I don't think we need to panic over. But rather we need to be aware of it and exercise caution and have contingency plans set aside just in case." As a final warning, Beedle adds, "The companies that exercise caution are going to come through very well. The companies that ignore facts are going to suffer." □

BY ALBERTO SOCOLOVSKY

Components: Growth areas in a slow-growth market

Not all the action is in silicon. SMT and other technologies are giving new life to passive components

Tony Hamilton's eyes brighten up considerably when he talks about semiconductors, less so when discussing connectors, and they get positively dim when the conversation turns to resistors. However, the changing countenance of Avnet Inc.'s chairman has more to do with the general economic outlook for those particular products, than with revenue derived from his Electronic Marketing Group (EMG).

Last year, EMG, the largest industrial electronics distributor in the United States, sold almost 70 cents of nonsemiconductor components for every dollar worth of semis. But while dollar projections for the U.S. semiconductor market call for an increase — ranging from 11% to 26% this year, over 1987 — growth may be limited to single digits for electromechanical, interconnection, and passive components. Even so, this market may add up to $14.7 billion in the United States this year.

Besides Hamilton's look, there are other signs that growth comes slowly for those components.

- There are the line cards at Hamilton/Avnet, Harper and Time Electronics (Avnet's component distributors), which show names of companies that have changed ownership more than once in the past few years, as well as companies that may do so this year.
- There are the membership rolls at the Electronic Industries Association's Components Group, which keep changing from divestitures and acquisitions.
- There are the leadtimes for most of these components, which, after lengthening in the last quarter of last year, show signs of stabilizing in 1988.

Application specific components offer manufacturers a welcome opportunity to make a profit

No start-ups

Nevertheless, there are some fast-track market segments. "There are no start-ups [to make passive components] in this country," says John L. Sprague, president of Sprague Electric Company. But there are three major growth areas in which Sprague, as well as most other suppliers, are investing, and where they expect to see sales and profits in 1988. These include application-specific components, surface-mount components and the automobile market.

Application specific (AS) is to these components what ASICs are to chips. Bourns Inc., for example, makes resistor-capacitor networks which are tailored to cutomers' requirements. For its Japanese customers, Bourns developed resistive trimmers housed in plastics optimized for the board soldering fluxes and temperatures common in that country. And Sprague builds complex networks but uses ceramics technology to make a monolithic component out of them.

For manufacturers accustomed to facing price competition from foreign vendors, AS components also offer manufacturers a welcome opportunity to make a profit. That's because the component's added value makes it worth more to the customer than the sum of its parts.

But Herbert J. Rowe, senior vice president for EIA's Components Group, worries that small manufacturers that develop AS components may not recover their costs if their customer's application doesn't fly. Just as with their colleagues in the gate array business, some companies which experiment with AS may have trouble getting paid for nonrecurring engineering costs.

Nobody ever called the components that were developed specifically

Growth may be limited to single digits for electromechanical, interconnection and passive components

U.S. market ($ millions)

	1987	1988
Capacitors	$2,200	$2,300
Connectors and interconnection components		
Backplanes	385	415
Coaxial	281	302
Cylindrical	869	947
Fiber-optic	73	68
Planar cable	268	291
Printed wiring	1,134	1,222
Rectangular	515	549
Sockets	252	267
Other	559	610
Printed circuit (bare) boards	1,800	2,150
Keyboards	400	450
Relays	770	793
Resistive components		
Potentiometers and trimmers	250	250
Fixed	290	300
Networks	150	180
Switches	520	540
Other components* ($ billions)	$3.0	$3.1
Total ($ billions)	$13.7	$14.7

*Batteries, cables, coils, crystals, displays, enclosures, fans, EMI filters, motors

Sources: Avnet, Bourns, Cherry Electrical Products, ELECTRONIC BUSINESS, Electronicast, Electronic Industries Association, Fleck Telesis, Henderson Ventures, Potter & Brumfield

for the automotive market "application specific." But that's what they were. In fact, the automotive market requires more custom applications than computer or communications markets. For the electronic speedometer of GM cars, for example, Thomas & Betts Corp. developed a socket into which Delco, a division of General Motors Corp., drops in and reflow-solders an EPROM chip. T&B, as well as most domestic suppliers, would also like to have Japanese auto makers that manufacture in the United States as customers. But first they must compete for that business with Japanese suppliers that are following their clients across the Pacific.

This can be difficult, though. "We make relays for autos," says Roy H. Slavin, president of relay maker Potter & Brumfield, "so we participate in this booming market. And our quality level is higher than the Japanese relays." But P&B's efforts to supply the U.S. factories of Japanese auto makers have been frustrated, Slavin says, because "they specify the components in Japan."

Auto makers, of course, are also committed to surface-mount technology (SMT), another growth area. Their designs call for using more of these components in 1988 and beyond, because SMT saves space and allows the incorporation of more electronic systems under the hood.

SMT started with passive components, so the technology may be more advanced in some cases than it is with semiconductors. According to N.V. Philips' Electronic Component and Materials (Elcoma) division, the largest manufacturer of components in the world and the inventor of SMT, 50% of the world's resistors and 44% of the capacitors used in 1990 will be surface-mount devices, versus 39% of ICs.

On the other hand, Ken Fleck of market researcher Fleck Telesis, says SMT has made inroads in only two types of interconnection components: IC sockets and printed circuit board connectors. In 1987, only 4% of the sockets were SM; the penetration may go up to 7% this year and to 30% in 1990, predicts Fleck. "Resistors and capacitors have only two or three leads," notes Fleck, "so it's easy for a machine to place them on the board and make contact."

Surface mount for passive components is a growth market

Worldwide demand for surface mount capacitors and resistors

	1985		1990	
	Units (billions)	Percentage of total	Units (billions)	Percentage of total
Capacitors	20.6	26%	48.6	44%
Resistors	17.3	22%	50.5	50%

Source: Philips Electronic Components and Materials

The big get bigger

At press time, AMP Inc., the largest maker of connectors and interconnection components, and eighth-ranked Molex, were bidding for ownership of Matrix Science Corp. The acquisition would open for either suitor the $1.6 billion U.S. military connector market, a market that Allied-Signal Inc. exited last year by divesting Amphenol and Bendix.

In Allied-Signal's case, the divisions were sold to an investment group that retains ownership in the United States. But EIA's Rowe finds it distressing that some components manufacturers end up owned by foreign companies.

OEM inventories are at their lowest level in 10 years thanks to programs such as just-in-time inventory control

"It makes it so much more difficult [for the United States] to regain its preeminence in component technology," Rowe says. The most visible recent example was the acquisition of TRW's capacitor operation by ShiZuki Electric Com. Inc. But the largest foreign acquisitor last year was Philips, which — by buying the remaining 42% of North American Philips — also bought NAP's preeminent position as the largest maker of nonsemiconductor components in the United States.

Conversely, TRW Inc., once second only to NAP as a broad-based components maker, has gone out of the business of manufacturing electromechanical and passive components, and it is still trying to divest its Connector Components division. There will be more divestitures this year. "Even big companies can't invest everywhere," says P&B's Slavin. (His own company was sold by AMF Inc. to Siemens AG two years ago.) But he sees a good side to divestitures, because the manufacturers end up in the hands of management who, like Siemens, are committed to component technology. "It's healthy for Sprague Electric to be a public company again," says Sprague.

Leadtimes and inventories

Meanwhile, Daniel A. Bechtel, director of corporate materials for Hewlett-Packard Co., notes that component makers have improved leadtimes. This has helped HP and many other electronic equipment manufacturers to reduce their inventories.

Market watcher Ed Henderson says that original equipment manufacturing (OEM) inventories are today at the lowest level in 10 years, thanks to programs such as just-in-time (JIT) inventory control, which helps cut component leadtimes.

Electronics Purchasing magazine's leadtime index shows that leadtimes for most components rose throughout 1987, but Cahners Economics, which uses the magazine data as a base, forecasts that the increase will slow down in the first half of 1988. Cahners says leadtimes may actually go down in the second half. The leadtime problem affects primarily military-specification connectors, an important market in dollars but made up of relatively small quantities of high-priced connectors. James Noll, director for materials at Northrop Corp.'s Defense Systems Division, complains that large connector suppliers lack the flexibility to provide special designs, or even slight modifications of standard connectors, on short order. "The [long] leadtimes pretty well stick," he laments. □

BY DAVID CARD

CAD/CAM/CAE: A return to double-digit growth

Despite Wall Street's recent woes, 1988 will show reasonable upturn for CAD/CAM/CAE vendors

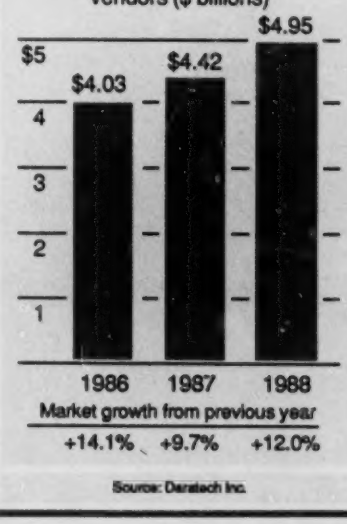
Slaves to capital equipment budgets, suppliers of CAD/CAM and CAE systems are anxiously watching for fallout from last October's Wall Street crash. If engineering and data-processing managers curtail spending, sales of systems for computer-aided design, manufacturing and engineering will rise only 10%, forecasts Charles Foundyller, president of market research firm Daratech Inc. But if capital spending ignores stock market uncertainty, world sales from U.S. vendors will go up 12% this year, to around $4.95 billion.

"The burning issue is the stock market crash. Are we or are we not going to have a recession, inflation or some other disaster?" Foundyller asks rhetorically. "Nobody really knows which way it's going to go. Most people say that they are choosing to ignore it." Adds Beth Tucker-Romig, an analyst who follows CAD/CAM/CAE at market researcher Dataquest Inc.: "One of the biggest determining factors wil be capital spending dependency on what happened on Wall Street. People will be pretty cautious in the first quarter." In fact, she says, that caution could extend through the first half of the year.

According to Daratech, the company with the fastest growth last year was electronics CAE leader Mentor Graphics Corp. Mentor president Gerard Langeler sees 15% to 20% industry growth. "The electronics segment is in pretty healthy shape, unless the stock market throws everything into a cocked hat — and I don't think it will," Langeler says. "I would say it looks pretty good. The people who buy electronics are reasonably healthy. The semiconductor companies are as healthy as they've been in some time. The computer companies are showing good quarterly reports. The aerospace companies are not as buoyant as they once were but the very rapid movement of technology has not abated, even through the business ups and downs."

Outside of the electronics segment, things still look pretty good, according to Daratech's second-fastest growing CAD/CAM manufacturer, Prime Computer Inc. Robert Fischer, president of Prime's CAD/CAM group, pretty much agrees with Langeler: "I would say that separate from the stock market turmoil, 1988 will show some improvement in the overall CAD/CAM market . . . It could get up to an industry growth rate of 15% or so." Like Prime, Intergraph Corp. has a strong mechanical slant, but George Ralls, responsible for strategic marketing in electronics, says that in electronics, Intergraph should easily see 20% growth over its 1987 $80 million in sales. "We've moved from 'guarded optimism' to 'real optimism,'" Ralls says.

CAD/CAM/CAE should bounce back — If Wall Street's crash hasn't induced a terror of capital spending among managers



There's at least one prophet of gloom in the industry. Michael Smith, a marketing director for Schlumberger Ltd.'s Applicon unit, sees drastic price cutting — due mostly to cheaper 32-bit engineering workstations — cutting into suppliers' top lines. "I think the whole market won't grow significantly because of prices coming down," Smith says. He says some Applicon lines have seen 45% to 60% price reductions recently. "Overall revenue will decline," Smith says, "I'm also sort of assuming a recession [this] year." Analyst Foundyller agrees on the effects of price erosion: "It's very easy making units grow; it's very difficult making revenues grow."

Consolidation at last

A trend sure to continue in 1988 is a thinning of the ranks. "We're definitely seeing the industry consolidation that has been predicted for some time," says Mentor's Langeler, "I don't think it's all done yet." Quips Prime's Fischer: "None of us can quite figure out why the shakeout that is inevitable in CAD/CAM hasn't occurred yet." Applicon has been hit by sales shrinkage and layoffs; McDonnell Douglas Corp.'s CAD division is only just profitable and General Electric Co.'s Calma is "just hanging on," according to Foundyller.

Meanwhile, there was a handful of mergers in electronics CAE last year, and Mentor acquired two companies. Mentor's mergers were not indicative so much of a shakeout as a broadening of the definition of CAE, Langeler says. Mentor agreed to merge with Caedent Corp. and Integrated Measurement Systems Corp. (IMS). Both companies have strong links to test: Caedent makes a simulator and faultgrader, and IMS makes a test system for prototype custom chips. The design-to-test connection can come from the opposite direction as well. Automatic test equipment leader Teradyne Inc. took a further step into CAE (it already sells a simulator) by agreeing to acquire another simulator company, Aida Corp., late last year.

The low end of the CAD market was particularly merger and acquisition happy — Intergraph took a 50%

equity position in, and Prime acquired outright, PC drafting companies. "One of the bottom-line messages is that, with Wall Street quote, 'drying up,' capital is harder to come by to buy market share. Mergers and acquisitions — although they are never easy — are an easier way to gain market share," Dataquest's Tucker-Romig says. The number of start-ups versus shutdowns has been almost equal for the last three years, she says.

Prime went through a flurry of deal-making last year. Besides buying Versacad Corp., a firm that sells software for personal computers, Prime brought out a high-end graphics workstation it developed along with Silicon Graphics Computer Systems and a medium-scale model from Sun Microsystems Inc. "One of the things I learned the hard way is that I don't think you can make money . . . as a value-added reseller of somebody else's hardware," Prime's Fischer says.

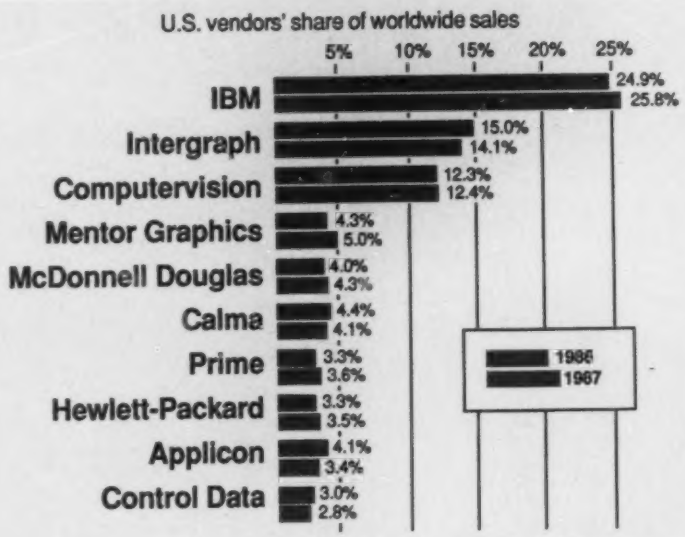
So why the deals? "Versacad —We just went out and bought them, so we can make money there," Fischer says. "We couldn't afford to buy Sun. That's a straight OEM deal and we won't make much money on that." A midrange computer was a must, Fischer says, and any Sun sales should "drag along some 50 Series computers" that Prime makes. Prime owns a piece of Silicon Graphics, so it was able to get a good deal on the hardware; and the two companies also divvied up marketing areas. "It's still going to be tight," Fischer says.

To bundle or not?

Much has been written about the trend of "unbundling" design software, that is, selling it separately from the computers it runs on. But in fact, none of the biggest CAD/CAM suppliers do it unless they absolutely have to. Actually, just the opposite is true, as the industry becomes dominated by computer companies like IBM and Prime, and systems integrators such as Intergraph start to build their own workstations.

Daratech's Foundyller explains that it is not only a matter of the big companies wanting to maintain their gross margins. They are afraid, he says, of losing control: losing account control by being the one sales point; and losing installation control by having to wait for hardware and operating environment control, by, for example, being forced to keep up with the latest operating system updates.

The CAD/CAM rankings: Mentor picks up share and Big Blue just keeps getting more of the market



Source: Daratech Inc.

"For [customers like] GM or Uncle Sam, they will do that," Foundyller says of companies unbundling software, "For anybody else, they won't. Systems integrators have a lot more trouble unbundling than computer vendors do."

"It's becoming an application that can best be sold by general-purpose hardware and system-software companies," says Fischer, whose company fits into the first category. "I've got to believe that at some point DEC will get into the CAD/CAM, CIM business on their own," he adds. Fischer likes to think of CAD/CAM as a piece of computer-integrated manufacturing, a train of thought that most of the big computer companies, including Digital Equipment Corp., like to board.

If engineering and data-processing managers curtail spending, sales of CAD/CAM/CAE systems will rise only 10%

"It is a systems business, they're right, but the question is: do you have to make the whole system?" asks Mentor's Langeler. He resells hardware from Apollo Computer Inc. Buying bits and pieces from a variety of vendors, Langeler says, begs "the 'Ghostbusters' question: Who you gonna call?" He thinks it likely that only the most sophisticated customers will want to deal with multiple suppliers. Applicon's Smith agrees: "As corny as it might sound, customers still want turnkey systems."

Dataquest's Tucker-Romig does not think that will hold up much longer. "Large companies have the most workstations, and they've got the voice and the pull," she says. "If your name is Hughes, you can back Mentor into a corner and they'll unbundle." She thinks that amount of pull, particularly in cutting deals with the hardware companies, will force the CAD/CAM suppliers to go software-only. "It's something they'll have to do," she says. "Hardware has not really gotten to the saturation point, but people are not going to buy as much as they did in the past." Dataquest forecasts sales growth of CAD/CAM hardware, compounded annually through 1991, to be at a rate of negative 1%, while software clocks in at over 20%. □

BY CAROL SUBY

Production equipment: a high-wire balancing act

Sales of everything from steppers to etchers will grow fast in early 1988. But look out for a slowdown in the second half

In these trying times, running a semiconductor equipment business is a bit like bicycling across a high-wire while balancing a cup of water on your forehead. Last October, just when everyone agreed that the upturn had arrived, the stock market slipped and fell. Talk of healthy backlogs and a return to profits quickly turned to questions of economic recession and its impact on the electronics industry. Once again, equipment vendors and their customers — the semiconductor manufacturers — are being faced with difficult forecasting decisions.

Despite the fact that many chip houses are nearing 100% capacity, both equipment vendors and their chip-building customers continue to be "cautiously optimistic." However, if the semiconductor industry as a whole sticks to the spending plans it had before October's Wall Street wash-out, 1988 should be a good year for its equipment vendors.

Worldwide sales of semiconductor manufacturing equipment — including wafer fabrication, assembly and test equipment — are forecast to grow 24%, reaching $7.1 billion by year's end, according to San Jose-based VLSI Research Inc. And, the sun is shining on just about every kind of production equipment.

"Everything is hot," says G. Daniel Hutcheson, director of VLSI Research. "The changeover to fine line widths — anything below 1.5 microns — is happening much faster than anyone expected. It's eating up capacity." But leading-edge equipment for state-of-the-art chips is not all that's selling.

Worldwide production of semiconductors is up considerably — growing 22% in 1987 to $44.5 billion and expected to grow another 23% this year to $54.7 billion — according to Joseph Grenier, senior industry analyst at San Jose market research firm Dataquest Inc. And the chip builders, which had been canceling equipment orders or putting them on hold, are now buying to retool older fab lines or to increase capacity across their product lines.

As a result, the equipment vendors are selling as much of their older-generation hardware as their newest-generation machines. In some instances "it's as if the old purchase orders that were canceled during the downturn are now being dusted off and sent in," says Stephen Balog, an analyst with New York City investment brokerage firm Prudential-Bache Securities Inc. Balog points to a "surprising resurgence" in demand for diffusion tubes, which, he says, were intended to be displaced by the newer chemical vapor deposition (CVD) equipment. Instead, Thermco Systems Inc., a major manufacturer of these tubes, has recently doubled its backlog from 100 tubes to 200 tubes, according to Balog.

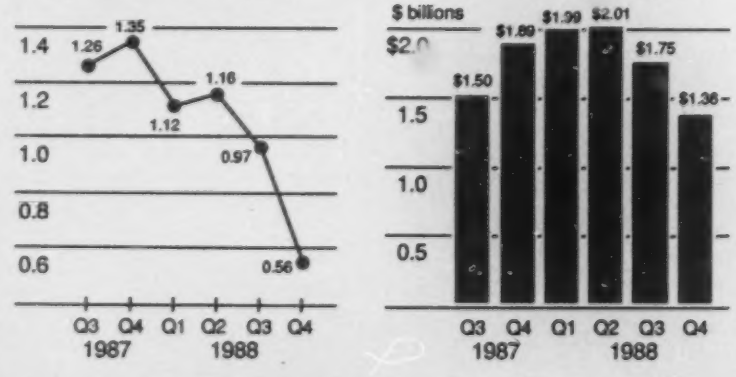
Worldwide sales of chip-making equipment are forecast to grow 24%, reaching $7.1 billion by the end of the year

Retooling older lines

Other equipment vendors are seeing more of the same. Production equipment giant Perkin-Elmer Corp. is selling a mix of equipment, not just its state-of-the-art gear. "We see both kinds of buying," says Stephen A. Reber, director of lithography equipment at the company's Norwalk, Conn., headquarters. According to Reber, a lot of older semiconductor production lines are being retooled; demand for bipolar equipment — an older manufacturing technology — is still growing; and, a lot of equipment is being purchased for 1.1 micron to 1.2 micron lines in production.

And, at Nikon Precision Inc., the U.S. subsidiary of Nippon Kogaku K.K. of Japan, about half of the equipment the company sells is for use in next-generation design rules and the other half is for retooling, says Michael Powell, vice president, marketing and services at Nikon's

Most of this year's growth in sales of semiconductor production equipment will take place in the first half of 1988



Source: VLSI Research Inc.

San Bruno, Calif., headquarters. A year ago, approximately 80% of sales were for leading-edge applications.

In addition, the buyers are as broad-based as the types of equipment that is in demand. From the major chip houses to the smaller specialty chip shops, fab floor space — idle for several years — is now filling up and, in some instances, new fabs are being built. At Texas Instruments Inc., leading edge products — such as dynamic RAMs and high-end logic chips — are "pushing capacity to its limits," says a company spokesman at TI's Semiconductor Group in Dallas. For example, TI's Houston fab — where 1-megabit DRAMs are manufactured — was half empty a year ago, but is now being fully utilized.

Capital spending plans for Silicon Systems Inc., an application-specific IC house based in Tustin, Calif., are being increased from 15% of 1987 sales to 20% of 1988 sales, according to Roy Lloyd, director of materiel. Already, SSI has taken delivery on a stepper — a million-dollar wafer-fabrication machine — as well as on three pieces of etch equipment, and "a whole slew of test equipment for the [back] end," according to Lloyd. The company's drive toward smaller geometries — line widths — is pushing some of these capital equipment expenditures, Lloyd adds.

Another ASIC house, VLSI Technology Inc., has been on an ambitious spending plan for some time while it retools its headquarters fab in San Jose and builds a new fab in San Antonio, Texas. However, after October's stock market crash, company executives quickly gathered to reconsider their 1988 spending plans. A decision was reached to keep its $50 million capital equipment budget for 1988 intact. (The company's 1987 equipment budget was $40 million.) Executives opted to look at other areas where cuts might be made if changes in the marketplace warranted such actions, according to a company spokeswoman.

Such aggressive capital spending plans are not limited to U.S. buyers. "In Japan, which was dormant for six to nine months, we're now doing a surprising amount of business," says Reber at Perkin-Elmer. And, PE is not alone in raking in the yen.

U.S. vendor Applied Materials Inc. — Japan's market leader in both epitaxial processing and plasma etch systems — is also experiencing a resurgence of business in Japan. According to Applied's senior vice president, James Bagley, in Japan, "there has been a 50% to 60% increase in activity [regarding] actual bookings and requests for quotes." But the buying doesn't appear to be broad based, he adds. Japanese customers are buying for two product types — ASICs and CMOS — and are looking to add capacity to support 1Mb production and 4Mb qualification, according to Bagley.

The bad news

All of this good news, however, covers only the first half of the year.

The book-to-sale ratio is expected to peak at 1.16 by mid-1988 and slow to 0.56 by the end of the year

In fact, for the equipment sector, more than two-thirds of this year's growth will take place during the first half of 1988. The book-to-sale ratio is expected to peak at 1.16 by the end of the second half of 1988, and then slow to 0.56 by the end of the year, according to VLSI Research. Despite the eventual tapering off of orders, "I don't think we'll see the boom/bust cycle we saw in 1984," says Hutcheson of VLSI Research.

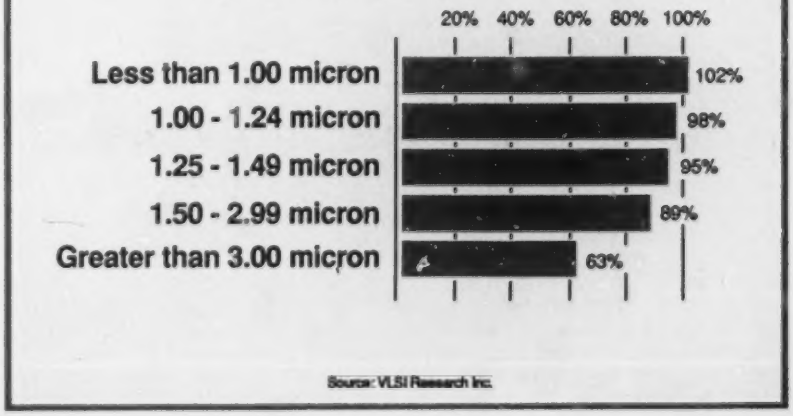
U.S. equipment vendors have "been to school" since that time, and by mid-1988 the lessons learned will be put to the test. Better business practices such as closer vendor/customer relationships, the scrutinizing of build forecasts, and keeping the lid on inventory have taken hold.

Today, production equipment vendors, "no longer sell just pieces of equipment. You have to sell the process," says Tony Jurvetson, president of Varian Associates' Semiconductor Equipment Group, in Palo Alto, Calif. At Varian, laboratories have been added where customers can come in and work on solutions. This sort of duplicate of a customer facility is very expensive, but also quite necessary, says Jurvetson.

Being so closely involved with the customer is becoming a key ingredient to success in a market that is developing into a globalized industry. Competition is no longer limited by national borders. In fact, several U.S. equipment vendors — Applied Materials, for example — have strongholds in various segments of the Japanese marketplace. At the same time, Japanese equipment vendors, including Nikon and Canon USA, are gaining shares of the U.S. marketplace.

However, the idea that Japan is getting stronger in the United States is "a myth," says Dataquest's Grenier. Pointing to Japan's less than 10% share of the U.S. wafer production equipment market, Grenier suggests that in this instance, "Japan could be demanding equal access in the U.S." □

Running at full capacity, many submicron chip makers need all the production equipment they can get



BY DAVID CARD

Test: An $8 billion market looks up in 1988

ATE is picking up the pace, thanks to strong chip sales. Instrument business will be worth writing home about too

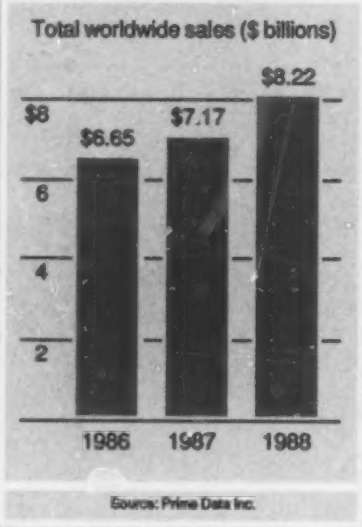
While it isn't exactly racing along, the test and measurement industry is growing solidly again. Barring any disastrous long-term effects from last October's stock market tumble, world sales should be up by well over 13% this year, to over $8 billion, according to market watcher Prime Data Inc. of San Jose. That's in comparison to a sluggish 7% annual growth rate last year.

"In general, 1988 is going to show strong growth," says Prime Data's Galen Wampler. Wall Street's grumbling bears "are not reflective of the industry," Wampler says. "The whole economy affects test instruments, but the stock market affects the psychology of the economy." Tektronix Inc. executive vice president Willem Velsink sees October's stock shock as a much needed, if drastic correction, and envisions a possible surge of takeovers. But he concludes: "I don't see the major recession. I don't see any real booming economy either."

Sales of automatic test equipment, which paced the overall T&M market last year, should once again gain momentum on the strength of the semiconductor industry, adds Kenneth Neff, who tracks the ATE sector for Prime Data. World sales should grow 18.8% in 1988, to reach a total of $1.99 billion. Neff says that he's also assuming little negative effect from Wall Street. But test suppliers had better take advantage of the mini-boom while they can — Prime Data is bearish on 1989. Neff says next year will slow, maybe even to the point of a recession. "You can pick your date for a recession and I'm sure you'll find somebody to fill it," Neff quips grimly.

Until then, "Bookings are up, business has definitely turned," says Edward Rogas Jr., vice president of the Semiconductor Test Division of ATE maker Teradyne Inc. As opposed to last year, chip companies are starting to buy production line machines, rather than the odd R&D tester for advanced product development. "We're seeing production orders as well as engineering orders," Rogas confirms. Teradyne is even adding to its own production capacity for some lines.

The test market, while it isn't exactly racing along, is growing steadily



World sales of ATE should grow 18.8% in 1988 to reach a total of $1.99 billion

Japanese chip tester Advantest Corp. echoes Teradyne's sentiments. "Certainly the indications are encouraging," says Advantest's U.S. president, Frederick Bihler. U.S. chip and computer companies "are starting to spend money." Bihler sees 15% growth into the first quarter, then another 15% in the six months following that. Another test company, LTX Corp., is not so sure things have turned around. Says president Graham Miller: "If there is [a turnaround for semiconductors], it's very spotty." LTX competitor Attain Inc. agrees. Says marketing manager Kenneth Chastain: "Things are picking up somewhat, but we're the tail end of the dog. The semiconductor companies have to pick up first, then we come along six months later."

A consensus is perhaps best expressed by John Zapf, a marketing manager at board tester GenRad Inc. "Nobody would say the business is booming, but it has rebounded. We're starting to see capacity buys. For years, there was no such thing," he says. Prime Data's Neff says that the board test industry, which was slower to slump, should likewise be slower to recover than the semiconductor test industry. John Scruggs, general manager for instrument giant Hewlett-Packard Co.'s board test unit, says, "We really believe we can see some real growth coming." Scruggs forecasts double-digit sales expansion, and is particularly keen on the telecommunications market. GenRad's Zapf has his own favorite hot market: "There are half a dozen PC clone makers doing well and buying from us."

Smoother sailing

It looks as if the sailing has smoothed in test segments other than ATE, as well. "We had a flat first quarter, but there was a comeback in the second," says Richard Jensen, vice president of Applied Microsystems Corp., a maker of microprocessor emulators. "We weren't much different from the rest of the T&M industry where we thought the world had stopped buying *anything* in the first quarter." Jensen says that Applied had $17.5 million in sales last year, and should continue its roughly 20% annual growth rate. Prime Data's Wampler says that microprocessor development systems, which incorporate emulators to write and debug software in systems, should at least track the general test market growth rate. Sales dollars had slumped recently, as suppliers began plugging development systems into

PCs and 32-bit workstations, rather than selling built-in computers.

In fact, Jensen sees the lure of the PC fading already, as true engineering workstations drop in price. "The PC opened up the entire [development system] business. But workstations are the trucks that are going to drive through the hole," Jensen says. He expects that the next wave of workstations could be priced as low as $3,500 per unit.

Development systems sales may be coming along nicely, but digital oscilloscopes are the real hot spot in instruments. Prime Data forecasts sales growth of over 25% this year in this sector. William Whitward, director of N.V. Philips' T&M business unit, says that Philips' biggest U.S. market is oscilloscopes. "And it's one of the most interesting, with the growth of digital oscilloscopes," he says. Even so, Philips, after a long hard go at the U.S. instruments market by itself, "did not meet the targets we wanted in the U.S.," Whitward admits. So it bought into the market.

Last fall, Philips put the finishing touches on a deal that gave it a 7.5% share of John Fluke Manufacturing Company Inc., thereby guaranteeing instant U.S. presence. Says Wampler of the deal: "From the perspective of the U.S., Philips has a lot to gain. From Fluke's perspective, they get a little more sales, but a lot more profits." Wampler thinks it is a good match overall, bringing the combined alliance into a strong No. 3 position in the world instrumentation market and closing the gap behind the No. 2 company, Tektronix. (HP is still a clear first.) "The test instrument market is going to keep getting more competitive, and this allows them to have a full product line, yet to concentrate on their own areas of expertise. That way, they can get the sophisticated instruments you need to tie into computer-aided engineering," Wampler says.

Digital oscilloscopes are the real hot spot in instruments. Prime Data forecasts sales growth of over 25% this year in this sector

Beefing up business

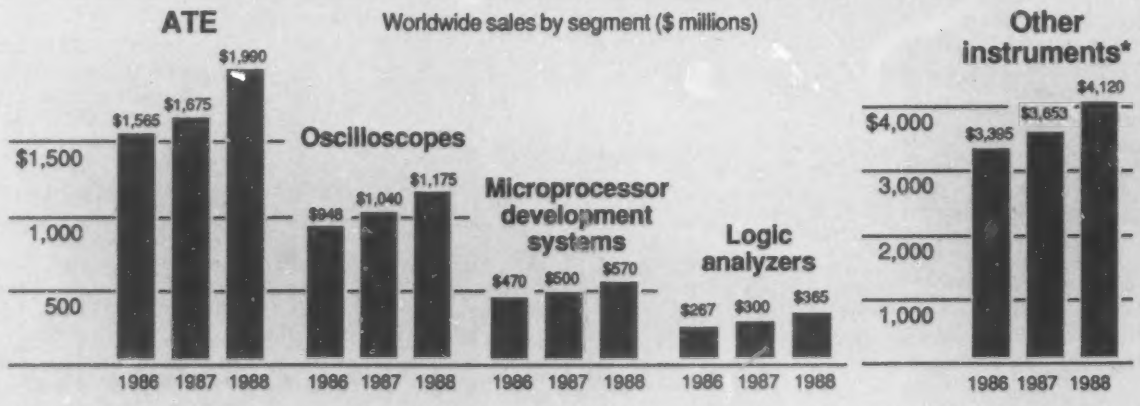
Fluke chairman John Fluke Jr. says his company can beef up Philips' business with the U.S. government. "If you're not in on the key government contracts, you're kidding yourself," Fluke says. "One of Philips' weaknesses was that they were not bidding on those aggressively enough." He says Fluke eventually could manufacture some Philips products in the United States.

Last July, five of the leading test instrument companies — Colorado Data Systems Inc., HP, Racal Dana Instruments Inc., Tektronix and Wavetek Corp. — took the wraps off a new set of specifications for modular instrument cards that they hope will become an industry standard. The goal of the so-called VXIbus, (for VMEbus extensions for instrumentation), is similar to that of an HP bus that it threw out to the world. HP's bus — now known as the IEEE 488 standard — became widely accepted by most instrument companies as the method to cluster instruments and control them from a single computer.

Prime Data's Wampler estimates that over 60% of all instruments sold are 488-oriented. "I don't think that the VXIbus will have a dramatic impact on 1988," Wampler says. But he thinks that in 10 years VXIbus could represent 20% or more of all instrument sales.

Tektronix chief marketing officer Philip Robinson speaks in a similar vein: "Personally, I think people will look back in five years and say this is one of the most significant events in the industry, but in one year, you won't be able to tell much." For one thing, he does not think the proposed standard will compete with the 488 standard: "We all have considerable investments in 488 instruments." However, he thinks it has the potential to be just as big an influence over the years as the HP standard has been. □

ATE picks up the pace in test growth. Meanwhile, digital scope sales are propping up the oscilloscope market



* Includes digital multimeters, voltmeters and signal generators

Source: Prime Data Inc.

BY STEVEN TITCH

Telecom gear: Coming through loud and clear

Developments in transmission equipment will drive telecom growth in 1988. Intelligent networks are already on the way

If this were Hollywood, the slogan would be "10 Years in the Making." Not that any of the usual motion picture promotion gimmicks are needed; the telecommunications industry has been hyping the convergence of voice and data since the late '70s. At last, it is beginning to happen.

The process brings together all the familiar telecom buzzwords of the '80s: integrated service digital network (ISDN); intelligent networks; local area networks (LANs); the T1 transmission specification; and network management. No longer is there a finite point where a private network ends and the public switched network begins, just as there is no longer a solid division between switching and transmission equipment.

If anything, these lines will become more diffuse as technology marches into 1988. "There's more distributed intelligence in the network. I'm having a hard time determining where switching ends and transmission begins," says Maria Sbrilli, an analyst with Smith Barney, Harris, Upham & Company Inc., New York City.

No matter where the division is made, transmission equipment will drive telecommunications growth in 1988. Dataquest Inc., a San Jose-based market research firm, projects 7% annual growth in 1988 for the entire industry. Dataquest estimates $155 billion in total revenue for the U.S. telecommunications industry by the end of 1987, with growth to $203 billion in 1991.

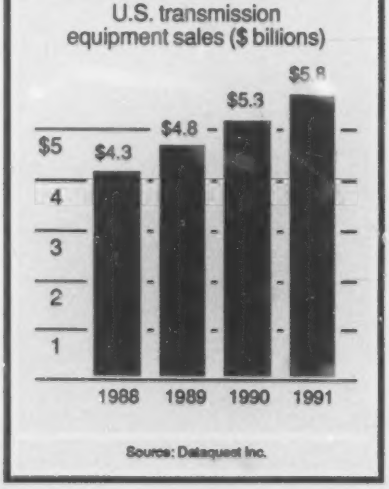
Sales of central office (CO) switches, the big ticket machines that switch and route local and long distance calls, will plateau at $3 billion and stay there until 1991.

"Growth is slowing in the CO market," says Vic Krueger, vice president of telecommunications industry services at Dataquest. "The old electromechanical switches are being replaced quickly. That replacement requirement is now diminishing."

Krueger says 1992 will be the first year CO sales will again grow significantly. That will be triggered as telephone companies begin to replace the analog stored-program-controlled switches that now serve approximately 50% of the lines in the national public switched network. These systems are expected to remain in service until their depreciation runs its full course, Krueger says.

But heavier demand for digital transmission equipment will pick up much of the slack. Intelligent network technologies such as ISDN require end-to-end digital equipment, and fiber-optic electronic components, digital loop carrier gear, and equipment that provides subscribers with special services will be finding their way into the network in great numbers. "Electronics has been rather late in entering the loop, which has historically been dominated by copper wire," Krueger says. "Now, the reliability of the new electronics has been convincingly proven."

Heavier demand for digital transmission equipment will help drive sales of telecom equipment this year



Dataquest forecasts a 10.4% annual growth rate for sales of transmission equipment through 1991, when total industry sales for this market segment should total $5.8 billion, compared with the estimated $4.3 billion in transmission business in 1988.

Satellite down-trend

Kenneth Bosomworth, president of market research firm International Resource Development, New Canaan, Conn., agrees. "There's going to be a downward trend in satellites, in fiber-optic cable, in private branch exchanges (PBXs) and in CO switches," he says. "However, there's going to be an upward trend in T1 multiplexers, modems and a strong upward trend in specialty voice service equipment, such as incoming call processors."

The only variable that could effect 1988 revenue has been the stock market tremors on Wall Street, and even that's proving debatable. In November, many pundits were talking about the possibility of a recession, and telecommunications analysts were split on how strong an effect it might exert on the industry. "In past recessions, AT&T's stock has done well," notes John Bain, senior vice president of New York City investment brokerage Shearson Lehman Brothers. "But we have not had a recession since the Regional Bell Operating Companies came into existence. We don't know what might happen."

Bain thinks carriers would be hardest hit because calling tends to drop during times of tighter money. Because a carrier's revenue stream is directly tied to the volume of calls placed on its network, a decrease in calling will hit it directly in the wallet. The knock-on effect is obvious: "Capital expenditures go right out the window," Bain says.

Others, such as Krueger, believe that telecom construction budgets have already been set in motion and if there is a major economic downturn, it would have little influence in changing the telecom companies' course. The Dataquest anaylst says market watchers would expect customer premises equipment would be affected more, and telephone services

to a lesser degree. "People don't disconnect their phones during a recession. Equipment used by the telecom companies as part of the network is typically not affected. Long term plans have already been made," Krueger says.

Recession or not, companies are lining up to grab more market share. AT&T, which has long dominated the transmission market, though still stocked with a quality array of wares, appears more vulnerable than ever to competition. Northern Telecom Ltd. has expanded its transmission equipment line through a joint venture with Britain's Standard Telephone & Cables. Meanwhile, Plessey Company Plc has merged its telecommunications operations with similar operations of fellow British company General Electric Company Plc (not connected with General Electric Co. in the United States). Not only will this make Britain more competitive in global switching markets, but it offers Plessey, which already owns Lake Mary, Florida-based Stromberg-Carlson Corp., a solid base of transmission technology to market on American shores.

In addition, Siemens AG of West Germany, is shaping up its Transmission Systems subsidiary in Phoenix, Ariz., which it purchased from GTE Corp. in early 1987. Further, companies such as DSC Communications Corp. of Plano, Texas; Tellabs Inc. of Lisle, Ill.; and Rockwell International Corp.'s Telecommunications operation in Dallas; which make multiplexers, cross-connect switches and other types of transmission equipment, all expect good business throughout 1988.

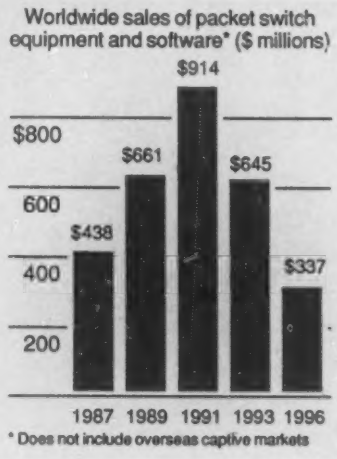
T1 time

"We see strong momentum continuing through the fourth quarter into 1988," says Brian Jackman, vice president for marketing at Tellabs. The headiest segment of the transmission market right now, however, is T1. The term itself comes from a telecom company specification for digital transmission at a rate of 1.5 megabits per second — the equivalent of 24 voice conversations combined into one big pipe. Now, however, it has come to signify a trend among computer users who, having built tens, even hundreds, of in-house local area networks over the past several years, are now linking them via data networks that cross oceans as easily as they cross town.

While T1 had found numerous applications in offices throughout the early '80s, only now is its future significance in the converging voice and data sectors fully being understood. Witness IBM's June agreement with Redwood City, California-based Network Equipment Technologies Inc. for joint development and marketing of T1 technology.

"Suddenly, there was a critical mass [of T1]," says Smith Barney's Sbrilli. "There was enough knowledge and enough of a comfort level at large organizations to go with T1. This is leading to a true convergence where distributed applications processing becomes an integral part of the computer and communications architecture and IBM can't ignore that."

Packet switches will be the big losers as fiber optics proliferate and intelligent ISDNs come on stream



Transmission equipment sales are forecast at 10.4% annual growth rate through 1991, when total industry sales should total $5.8 billion

Neither is IBM ignoring the evolution of the intelligent network. As telecom companies look for ways to distribute more and more intelligence in the network, IBM has signed agreements with Siemens, and L.M. Ericsson Telephone Co. of Sweden to develop interfaces for their respective switches. Meanwhile, it has pursued pacts with United Telecommunications Corp. and MCI Communications Corp., of which it owns 25%, to develop software for the service control points, the network nodes that will contain databases for future advanced services that will be offered by the local exchange companies or private agencies known generically as enhanced service providers.

In the trenches with IBM is Maynard, Mass.-based Digital Equipment Corp., which has been following its own strategy for integrating data and voice in public and private networks. Both computer companies are thrusting into telecommunications in a big way. Their full impact will be brought to bear on the market in 1988 and it is enough to make IRD's Bosomworth hedge when asked about industry growth. "It really depends on if you start defining data-processing equipment as telecommunications equipment," he says.

Yet as the year begins, questions will continue as to how telephone companies will be able to implement future advanced services that an intelligent network would make possible, such as electronic Yellow Pages, voice mail and videotext. The U.S. Justice Department has yet to lift most of the restrictions on the Bell Operating Companies regarding information services contained in the AT&T divestiture settlement.

ISDN needs

ISDN, on the other hand, should move more quickly. This new technology — the ultimate convergence of voice, data, facsimile and video — will see its first-ever commercial deployment in Japan this March. Throughout 1988, ISDN islands, or "concentrations," as Paul Bayliss, vice president for market planning and management of AT&T Network Systems, likes to call them, will appear more and more in the United States. "As ISDN's functionality grows, its need will grow," Bayliss says.

The new technology could spur demand among semiconductor manufacturers as switch manufacturers will require ISDN chips and chip sets. AT&T has already signed an agreement with Motorola Inc.'s Austin, Texas, Semiconductor division for an ISDN integrated circuit that will han-

dle certain network management functions.

The initial cost is expected to be expensive, but then prices are expected to drop. "We're at the start of the learning curve," states Peter Thomas, president of Ericsson Inc., Richardson, Texas, the U.S. subsidiary of L.M. Ericsson. "We're still developing custom circuits. As time goes on and volume grows, the cost will drop." Thomas says ICs that cost $25 apiece now could ultimately drop to $1.50.

Questions remain, nonetheless, as to how popular and widespread ISDN will be as it becomes available. Critics say large users have private networks that perform a great amount of ISDN-like functions already. The cost of ISDN services is still unclear. Even as ISDN approaches reality in Japan, Nippon Telegraph & Telephone is unsure how it will package and price it.

The big loser

Through all of this, packet switches appear to be the big loser. While sales growth will continue until 1990, the ubiquity of fiber optics, and the surge in ISDN — which integrates packet network functions — will start to depress the market. According to International Resource Development, the packet switch market will grow from $650 million in 1987 to $1 billion in 1989, then peak at $1.6 billion in 1991. The market would then start downward to $1.56 billion in 1993 and $1.21 billion in 1996.

Questions remain as to how popular and widespread ISDN will be as it becomes available

Fiber-optic technology will also gain at the expense of satellites. A recent study by Technology Futures Inc., Bethesda, Md., done for Martin Marietta Corp., concluded that fiber optic cable has become the primary medium for U.S. long-haul communications, thereby supplanting satellites. In addition, Bell Communications Research Inc., the research and analysis operation owned by the seven Regional Bell Holding Companies, is already investigating the use of fiber for network television transmission, a method that if successful, would further erode demand for satellite transmission capacity. □

BY BRUCE C.P. RAYNER

Distribution: Keeping a watchful eye on OEMs

Prospects for growth are good but many worry about uncertainties on Wall Street and ship-and-debit abuses

Plain and simple, the $7 billion electronics distribution industry is at the mercy of original equipment makers. If original equipment makers (OEMs) suffer, then so do their distributors.

So it comes as no surprise that many of the top distributors became very jumpy this fall when the stock market took a nose dive. The fear is that uncertainty on Wall Street will fuel economic pessimism, bring on a recession and send distributors diving for cover.

This kind of reaction would dash hopes of solid growth for 1988, which many distributors were forecasting. The optimism that had such a firm grip in September continues to relax and a new caution has entered business plans for 1988. The greatest fear is that this somber mood will fuel the self-fulfilling prophesy for an economic downturn.

Most distributors are feeling helpless. "All we can do is react to the marketplace," comments Gordon Marshall, president and chairman of El Monte, California-based distribution company Marshall Industries. However, "if the economy does not turn into a recession, then we will do quite well," he adds. Marshall is forecasting growth in excess of 20% for his company, *if* the recession can be held off through the year.

Charles Smith, senior vice president of Hall-Mark Electronics Inc. in Dallas, shares Marshall's concern about Wall Street. "Business has been pretty strong," he says, "and up until the developments in the financial markets, I was pretty bullish." But while he puts 1987's growth at a healthy 20%, Smith says there is a big question mark hanging over 1988.

A PC-led recovery

Despite the growing uncertainty in the market, Toby Mack, executive vice president of the National Electronic Distributors Association (NEDA), is sticking with his October forecast of 16% revenue growth for 1988. "There is no way to predict the effects [of Black Monday in October]," says Mack, so NEDA is not going to try. Besides, both August and September produced very strong growth in billings, indicating that there is considerable strength in the economy that the Wall Street bears are overlooking.

Usually, the month of September

Profitability: A major worry for distributors

Averages for 13 publicly held distributors, excluding Avnet Inc.

	1st quarter 1987	1986	1985	1984
Sales ($ millions)	$696	$2,569	$2,354	$2,857
Net income ($ millions)	-$2	-$53	-$1	$77
Net profit margin	-0.2%	-1.3%	0.0%	2.7%
Return on equity	-1.3%	-6.1%	0.0%	15.9%

Source: The Chicago Corp.

posts a 4% growth, but in 1987 it rocketed up 9%. Mack attributes this strength to a "PC-led" OEM recovery, coupled with a relaxation of a tight inventory discipline that many companies have maintained over the past year or so. There is some inventory building going on, he says, partly due to increases in production and also as a hedge against expected price increases. Prices of components, including semiconductors, are firming, as fears of shortages spread. So, many OEMs are buying now, says Mack. Because business conditions continued to improve through 1987, NEDA upgraded its annual growth rate for 1987 from 12% to 14%.

Charles Clough, president of Wyle Laboratories, a distributor based in El Segundo, Calif., agrees with Mack that 1987 was a very strong year, and points to Wyle's distribution sales increase of $70 million over 1986 as proof. Quarterly growth of 10% in semiconductors — about 63% of Wyle's distribution business — was attributable to balancing of inventories, increases in prices and an increase in consumption, says Clough. For systems, the growth was based on increases in demand. Unlike his competitors, Clough is optimistic about 1988. He puts Wyle's growth at 26% to 28% in semiconductors, and 33% to 34% in systems.

Pundits agree that the two strongest growth areas in distribution for 1988 will be semiconductors and computer systems. Semiconductor consumption in the U.S. is forecast to grow 20.1% in 1988, the same rate as 1987, according to the Semiconductor Institute of America. But NEDA's Mack says 16% is more in the ball park for distribution sales.

Similarly, the computer systems market, estimated at about $100 billion in total, will be one of distribution's main targets. Even though margins in systems are lower than in components, the sheer size of the market makes it appealing. Pundits expect the distributors' share of the systems market to reach $2 billion in 1988.

Anthony Hamilton, chairman and chief executive of top-ranked Avnet Inc., the New York City-based parent company of Hamilton/Avnet, says 1988 looks pretty good, despite the roller coaster stock market. "We will be ahead by about 33% of the average growth of what NEDA says, because of all the things we have in the mill," says Hamilton. That puts H/A's growth for 1988 up over 21%.

This fall, NEDA forecast 16% revenue growth in 1988, and so far, few distributors are ready to contradict that projection

The programs Hamilton is so confident about are the computer systems division and value-added services. Digital Equipment Corp. is plugging for H/A to do about $500 million in Digital sales by 1990. Also, H/A is hot on the application-specific integrated circuit design trail, particularly gate arrays.

Although ASICs are not for every distributor, H/A is very committed to boosting its business. Hamilton expects to be one of the "select few" who will survive in the market over the long run. Currently, the company is just about at break-even, says Hamilton, although almost every penny is being reinvested.

But tempering his enthusiasm for 1988, Hamilton says that the stock market crash could well have an adverse impact on growth, particularly in computer systems. "We will just have to wait and see how much of an impact the decline has had on the thinking of corporate business executives in the managing of their businesses and their intentions to invest in capital equipment," he says.

But growth is not the only concern on the distributor's mind these days. Competition ranks pretty high too. With the field of "national" distributors growing, the competition gets fiercer and the pressure on the small players grows in intensity. Last September, the industry took one more giant lunge toward maturity, which will reverberate for many years to come.

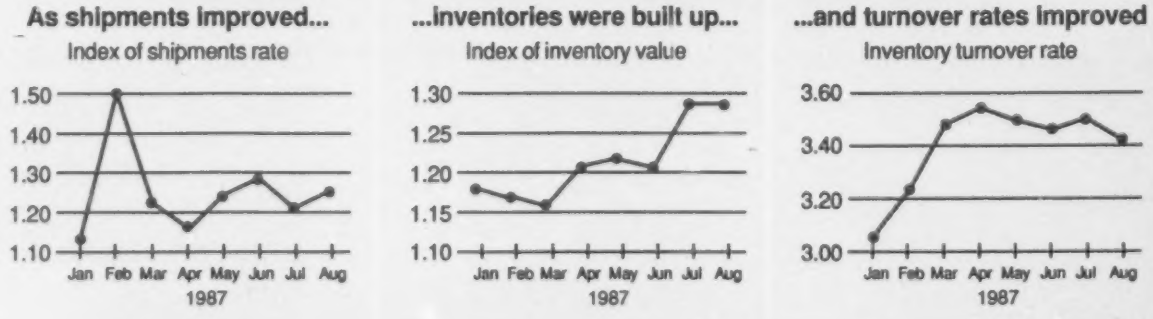
Arrow shoots to kill

That event was Arrow Electronics Inc.'s acquisition of three divisions of its fifth-ranked competitor, Ducommun Inc., including components distributor Kierulff Electronics. Most industry analysts, competitors, customers and suppliers agree that the $130 million purchase was a healthy move for the industry.

The reason it is beneficial, says Robert Throop, chairman and chief executive of Anthem Electronics of San Jose, is that overcapacity and overdistribution are destroying profits. "This long-term dilemma will necessitate the reduction in the number of participants," he says. Ducommun just happens to be the first to go.

Many distributors speculate that

For distributors, 1987 was a year of improvement



Source: National Electronic Distributors Association

since Arrow has now set the precedent, it is just a matter of time before other takeovers or mergers are announced. "The potential does exist for mergers in our business," comments Hamilton, "and it may be that we will have one or two more before the end of 1988." He points to the possibility of "foreign" companies buying into distribution because "distribution is much more respected from outside the U.S. than from inside," he says. Hamilton declined to comment on who those foreign companies might be.

Pundits agree that the two strongest growth areas in distribution for 1988 will be semiconductors and computer systems

On the whole, Hamilton agrees with his peers that the Arrow acquisition was a good move, even though Arrow is now within striking distance of his company. Estimates of the total size of Arrow's sales after the merger range from $600 million to $900 million, depending on how much of both company's sales Arrow will be able to retain. Most analysts speculate that whatever the outcome, one plus one will undoubtedly equal two. Defections of key personnel, as well as customers splitting their business between Arrow and a new competitor, are both factors in this equation.

"It will take a lot of skill on the part of [Arrow's] management to have all branches functioning perfectly after the merger," says Hamilton, "and I can tell you from experience, that an adjustment period is always necessary before true efficiencies are obtained."

Stephen Kaufman, Arrow's president and chief executive, says that the most crucial element in the "adjustment period" will be tying Ducommun into Arrow's in-house computer system. Arrow's technicians have been working on the issue since last September. In his typical upbeat fashion, Kaufman says the in-house computer network will be completed shortly: "We measure it in months, not in quarters, as to how long it will take," he says.

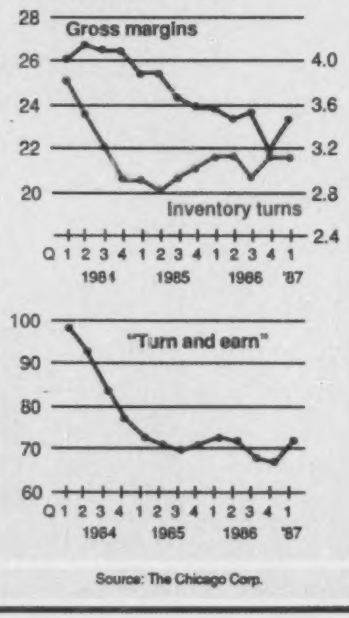
While the next few months will be crucial to Arrow's transition — and to the structure of the industry — there are some very troubling long-term issues that all distributors are being forced to confront. The most fundamental one is the lack of industry profitability. Without a return to profitability in the industry, the ability for distributors to raise equity capital will be dangerously limited, argues Clarke Walser, senior vice president of The Chicago Corp., a market research firm. Equity is the major source of financing for distribution these days.

Walser studied 13 publicly held distributors, excluding Avnet, and found that in aggregate, they had not had a profitable quarter since the second quarter of 1985. The reason can be traced to poor inventory management. Inventory turnover — the measure of how many times a year a distributor sells his stock — has declined from its "normal" level of four times a year to about three times a year for these 13 companies, estimates Walser. Similarly, NEDA reports that its August 1987 inventory turnover rate for its members averaged around 3.43.

Walser claims that while the turnover rate has been dropping, so has the distributor's average gross margin rate. From a high of 26.4% in late 1984, the gross margin of those 13 distributors fell to 21% by late 1986, and is hovering at around 23% today.

The cause of poor profits for distributors: Low inventory turn and declining margins

Aggregates of 14 publicly held distributors, including Avnet Inc.



Source: The Chicago Corp.

Multiplying the gross margin by the turnover rate and by 100, gives the "turn-and-earn" ratio, an index of profitability. Ideally, says Walser, this figure should be over 100, but for electronics distribution, the ratio has been down in the high 60s and low 70s for the past three years. "That is not adequate to produce an acceptable return on investment," says Walser. On the approximately $1.2 billion in total inventory that the distribution industry needs to service its customers, and given a 15% return on investment, profits should be up around $180 million a year, he adds. Second-quarter 1987 profits were a paltry $15 million.

Ship-and-debit debacle

One way the industry can improve its management of inventories is by overhauling the ship-to-stock and debit program. Ship-and-debit, as it is called, allows distributors to sell inventory at below the carrying cost and then debit the supplier for the difference. The original intent of the program was to give quick delivery and good service on large orders. But now it is being used for small orders. The administrative costs of processing the paperwork, coupled with the over-inflated book value of inventories, is depressing gross margins and cutting into distributors' profits.

Hamilton/Avnet's Hamilton calls the state of ship-and-debit "ridiculous" and believes that it is a major area of "profit leak" for the industry. He estimates that "a shocking 80% or more of ship-to-stock and debit is done in areas of $500 line items or less." As a result, "no one makes money," he adds.

While the debate at this stage is reduced to finger-pointing between distributors and their suppliers, there are a few constructive steps being taken. NEDA is formalizing recommendations, including suppliers taking a one-time hit by reducing costs and changing their pricing policies; Arrow Electronics is limiting its ship-and-debit orders to $50, according to an Intel Corp. source; Motorola Inc. is expected to make a stand on its ship-and-debit policy within the next few months; and other distributors are working on direct computer-to-computer links with suppliers, which would eliminate paperwork. □

BY ANNE KNOWLES

Software: IBM casts a bigger shadow in 1988

But with sparkling growth and a $24 billion market, who can complain? Look for OS/2, more Unix and more mergers

While everyone else is warily watching the economy, the software industry may be wallowing in glorious growth. Sales of all types of software — including systems, tools and applications —should jump nearly 23% this year, to $24.4 billion, according to Input, a market research firm in Mountain View, Calif.

While that figure is down from the 35% growth of the software industry's heyday in the mid-1980s, it is well ahead of the computer sector's single-digit advances. Revenue for systems software, which, by Input's definition, includes systems control software, data center management and application development tools, should jump 25.8%, from $9.56 billion last year to $12.03 billion in 1988. Revenue from application packages is forecasted to reach $12.39 billion, up 19.7% from last year's estimated $10.34 billion in sales. These figures, as forecasted by Input, are based on worldwide sales of U.S. hardware and software vendors.

The industry, though, will not entirely escape the economic fallout. Software vendors will have their eyes on the bottom line as much as anyone else. Start-up software companies may have a difficult time raising more equity from venture capitalists, says Harvey L. Poppel, partner at Fort Lee, New Jersey-based merger and acquisition specialist Broadview Associates. Pension funds, which historically provide much of the capital used by venture capitalists, took a beating in last year's market crash. Venture capitalists, in turn, may have few funds to offer young companies. And maturing, privately held companies that had hopes of raising equity through the public market have had to postpone plans of taking their firms public.

Software companies in need of cash, says Poppel, may have one of two choices. "Either they will go out of business or they will have to be acquired," he contends. That may lead to an even bigger boom in mergers and acquisitions in an industry that is already flooded with such deals. In the first nine months of last year, according to W.T. Grimm Inc., a mergers and acquisition firm in Chicago, there were 65 mergers or acquisitions in the computer software supplies and services industry, for a total value of $1.78 billion. Broadview's Poppel believes that buyouts of software companies will accelerate this year beyond the 10% to 20% growth in acquisitions which he had expected, due to the pinch in both private and public funds.

Sales of all types of software should jump nearly 23% this year, to $24.4 billion, well ahead of the computer sector's advances

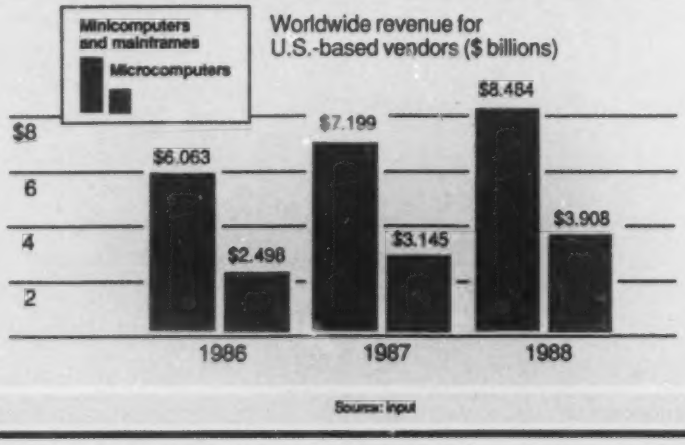
Poppel foresees further globalization of the software industry due, in part, to the acquisition binge. Last year, Broadview participated in a number of deals that involved U.S. and foreign partners. Among the deals was a software unit of Dun & Bradstreet, which was bought by France's Thomson CSF; a British software company which was purchased by Nynex, a U.S. Bell Operating Company; and a $35 million U.S. software firm which was sold to an Australian company.

More overseas sales

Another reason software companies may turn to global markets is the threat of a slowdown in the U.S. economy. Ted Jastremski, a software analyst with market researcher International Data Corp., in Framingham, Mass., contends that this year software companies will begin to increase their foreign sales. Application packages, especially, which have not been sold extensively overseas, will begin to gain more revenue from foreign markets.

However, the software industry, like all other high-tech industries, cannot escape the influence of IBM. The most significant software event in 1988, analysts agree, will be the delivery of OS/2. The new generation microcomputer operating system

Application software sales are growing faster for microcomputers than mainframes and minicomputers



from Microsoft Corp., co-developed with IBM, began customer shipments last month. Two more IBM-proprietary versions of OS/2 will come later in the year. The Standard Edition Revision 1.1, which incorporates IBM's graphics interface derivative of Microsoft's Windows program, called the Presentation Manager, should have initial customer shipments in July. And IBM's OS/2 Extended Version — with the much-awaited proprietary Data Base Manager and Communications Manager — is scheduled for delivery in November.

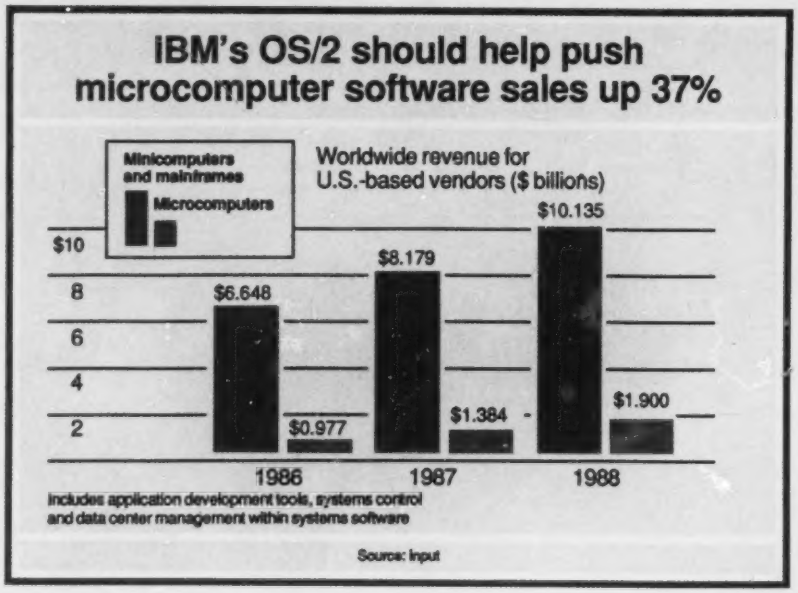
Existing application packages will be rewritten for OS/2 immediately, say most analysts. Companies with popular packages written for MS/DOS, the current operating system for IBM's Personal Computers, will rush to market with identical packages for OS/2, says Mike Cohn, a software industry analyst with Input.

But new applications, written expressly for OS/2, won't start appearing until mid-1989. Cohn says that software vendors are waiting to write for the later editions of OS/2 so they can take advantage of the operating system's graphics, communications and database functions.

"There will be a dramatic increase in networking and applications working together," due to OS/2, said William H. Gates, chairman of Microsoft, at a recent software seminar. Gates also believes that new applications will become increasingly graphic. And S. Jerold Kaplan, founder of Go Corp., a software firm in San Francisco, believes new classes of applications, like Lotus Development Corp.'s recently announced Agenda, will highlight software activity for the next few years. Agenda, developed by Kaplan, former Lotus chairman Mitch Kapor and Lotus R&D vice president Edward Belove, is similiar in purpose to a database, but uses artificial intelligence techniques to help users organize information. "There will be tremendous growth in new applications in the next few years," says Kaplan. "And there is plenty of room for expansion. There is more to life than slugging it out in the word processing, spreadsheet and database markets."

IBM's wrench throwing

Even so, IBM's proprietary Data Base Manager may throw a wrench into the increasingly competitive microcomputer database management system (DBMS) market. Currently dominated by Ashton-Tate, the market is being entered by a number of other DBMS vendors, such as Informix Software Inc. and Oracle Corp. And rumors have it that Lotus and Microsoft, which have never offered DBMS products previously, will also enter the market soon. But Input's Cohn says that in the nine months before IBM's product is available, existing and potential players can entrench themselves in the market. Customers that are not interested in networking their computers will opt for OS/2 Standard Version, without the database engine, thus leaving their DBMS decisions open for competition.



In the first nine months of last year, there were 65 mergers or acquisitions in the software supplies and services industry

Mainframe DBMS vendors, such as Cincom Systems Inc. and Cullinet Software Inc., will introduce database products for mid-range computer systems, an area in which Informix, Oracle and Relational Technology Inc. dominate.

Input's Cohn thinks that other software tools will take off also. Computer-aided software engineering (CASE) products are getting more attention from bigger names. For example, General Electric Co. and Cadre Technologies Inc., a Providence, R. I. CASE company, are developing software together; DBMS supplier Oracle has announced CASE software; and Big Eight accounting firm Arthur Andersen & Co. is offering CASE products. All will lend credibility to the somewhat maligned CASE market, says Cohn.

The fastest growing area of systems software should be data center management, expected to jump 29.8%, to $2.84 billion in 1988, according to Input. IBM dominates the field, but last year's acquisition of Uccel Corp. by Computer Associates Inc., IBM's toughest competition in the market, created the industry's largest independent software vendor. The merged software companies, with a combined 1986 revenue of $407 million, pushed Lotus into second place.

And systems control software, which includes operating systems and networking systems, should reach $5.092 billion this year, up 29.4% from last year, estimates Input.

OS/2 helps Unix

OS/2 may indirectly give the Unix marketplace a push. Paul Cubbage, an industry analyst with Dataquest Inc., in San Jose, thinks that while vendors convert existing packages to OS/2, they will also bring out the same packages for Unix. In addition, vendors will offer MS/DOS running under Unix, before OS/2 arrives. Already, says Cubbage, IBM and Prime Computer Corp., the Natick, Mass., minicomputer maker, have announced products that merge the two operating systems, allowing users to

utilize 32-bit microcomputers as multiuser machines. "It will expand the base of Unix applications, especially those applications that have been popular in the PC world," says Cubbage.

And the issue of Unix standards may finally be put to rest this summer when the IEEE (Institute of Electrical and Electronic Engineers) POSIX standard for Unix is published. X-Open, the European consortium of companies established to promote open architecture standards, is heating up the Unix market across the Atlantic. All in all, Cubbage expects the total Unix market to hit $3.9 billion this year and grow at an annual compound rate of 42%, until 1990, when it will reach an estimated $7 billion.

Big Blue's influence will extend beyond operating systems. The Armonk, N.Y., company's new Applications Software division should start pursuing deals with software vendors this year. The division's immediate intention, stated by vice president Joseph Guglielmi when it was formed last July, is to encourage writers of minicomputer software to develop packages for IBM's 9370 mid-range system. But software vendors have also been wary, afraid that IBM intends to compete directly with them in the applications market. To assuage those fears, IBM has informed its partners of the areas Big Blue will target itself.

IBM will be aggressively trying to protect its software sales, which increased 22% to $4.5 billion in the first nine months of last year

But IBM will be aggressively trying to protect its software sales, which increased 22% to $4.5 billion in the first nine months of last year. While maintenance revenue has declined and hardware sales have stagnated, except in the microcomputer arena, software is the fastest growing area for IBM. And IBM is getting increasingly savvy. "IBM knows they have to play in that market as a software vendor, not a hardware vendor," says Input's Cohn. "1988 will be the bellwether year for IBM's [Applications Software] division. We'll see whether it has an impact on the industry." □

BY PAULA DOE

Materials: Increased prices bring back profit margins

The soft market has kept most materials prices flat since 1984, but all that could change this year

Electronic materials suppliers should finally see double-digit sales growth again in 1988, provided demand remains strong enough to support price increases.

Fabrication materials will see 20% growth in 1988, while sales of packaging materials should climb 25%, according to "Electronic Materials Report," a market newsletter put out by the materials market research firm Rose Associates in Los Altos, Calif. "It will look like a boom year," says Daniel Rose, EMR's publisher. "But in actual fact it's not really all that exciting."

That 20% to 25% growth breaks down into a 10% average increase in volume, combined with a 10% price increase for wafer fabrication materials, and a 15% price increase for packaging materials. "Packaging prices will go up a little more," says Rose, "Because 75% of all packaging comes from Japanese makers, and they are going for a little more because they are trying to recover from the high yen. Volume growth could be as low as 5% if the economy goes flooey."

The soft market has kept most materials prices flat for the past three years. Materials makers see few dramatic increases in yields or major economies from mass production, to bring down their costs. A 10% price increase just about makes up for three years of 3% annual inflation in production costs. What's more, materials makers have had to contend with a recent surge of 20% to 40% in their costs for major raw materials such as gold, silver, aluminum and copper. And customers continue to demand ever purer, more sophisticated materials, which are more expensive to develop and produce, but not necessarily more profitable to sell.

"I have mixed feelings about the move to producing Cadillac devices," notes William Cruickshank, executive vice president for sales and marketing at leadframe maker Shinko Electric America in Santa Clara, Calif. "Making them slows down the whole process, and even when you ship the part, often the customer is not ready to handle it. We charge more for the more complicated devices, but they cost more to make.

Despite advances in new technology, 1988 is still not likely to be the year of the 8-inch silicon wafer

We're not necessarily making more money on them."

"We have to invest in technology to satisfy our customers if we're going to be in this business," adds a spokesman for Monsanto Electronic Materials Co. of Santa Clara. "That takes money, and we're not making it. We're just coming back into breakeven. Our price level is below what it was in 1982."

While there's still a glut of production capacity overall, demand for some sophisticated materials needed for making high-density semiconductors and other advanced devices is expected to exceed supply in 1988, keeping prices up. Makers of electronic materials ranging from silicon wafers and specialty gases to leadframe alloys and ceramic packages, took advantage of strong demands by raising prices 5% to 30% in the final months of 1987.

"There's a difference between leading edge capacity and jelly bean capacity," notes the Monsanto spokesman. "We are going to sop up existing capacity in prime areas." Wafer makers report that the demand for epitaxial wafers, large diameter wafers (above 150mm), and wafers with particularly tight specifications is already

straining capacity.

Monsanto sees double-digit growth and a return to profitability in 1988, thanks in part to its recent price increases of 5% to 20%.

"We expect 12% wafer growth now for 1988," predicts Tad Shimada, vice president and general manager of OTC America Inc., the Santa Clara-based U.S. subsidiary of the Japanese wafer maker Osaka Titanium Corp. "Prices are also going up from now." He notes that wafer prices in Japan are already 20% to 90% higher than in the U.S. because of stricter user requirements and a lack of exchange rate problems. OTC's production of epitaxial wafers is running at 90% capacity. While the company is readying new facilities to double that epi capacity early this year, it is having some trouble finding enough qualified people in rural Kyushu to replace the 150 it laid off last year.

Added silicon capacity

What about that rush of new Japanese silicon wafer capacity? "I think we're safe for two more years," says Shimada. New entrants like Nippon Steel are said to be having problems with yield and have yet to get big volume orders. Established Japanese wafer makers, however, are already adding more capacity in key areas. Besides OTC, Komatsu Electronic Metals and Toshiba Ceramics are also adding wafer production facilities.

Even so, 1988 will probably not be the year of the 8-inch silicon wafer. OTC, which sold the big wafers in sample quantities to IBM, NEC Corp. and Fujitsu Ltd. last year, reports these big users have stopped buying. They aren't likely to start again until a massive demand for some product allows producers to take advantage of the higher yields of the big wafers.

Fabrication materials will see 20% growth in 1988, while sales of packaging materials should climb 25%. Only 10% of this growth is due to volume increases

But as it turns out, 1988 may be the year in which materials for packaging for surface-mounted devices finally take off. EMR projects that by the end of 1988, SMT leadframes will account for 20% of all leadframes used by U.S. semiconductor makers in the U.S. and in their Asian assembly plants. This figure is up from 10% at the end of 1987. EMR sees SMT frames reaching 32% of all leadframes by 1990.

Demand is also pushing at the limits of leadframe makers' current capacity to supply etched leadframes, the fine line devices favored for high pin count, and small volume devices such as sophisticated application-specific integrated circuits.

"We see about 10% increase in unit volume overall, and prices will stay about the same," predicts Michael Lamble, U.S. marketing and sales manager for International Leadframe Corp., the U.S. subsidiary of Mitsui High-Tec Inc. "But there are a lot of new products in etched leadframes — new custom products, low volume, high pin count products —so we may see 20% to 30% growth in etched. That's one of the areas where there are capacity constraints, so lead times will likely stretch out." And, he adds, "SMT is going out of sight."

Over at Koltron Corp., a small producer of etched frames in Sunnyvale, Calif., national sales manager Joseph Herriges asserts that a shortage of industry capacity to etch fine pitch leadframes for the ASIC market could double prices by mid year. He expects etched frames' share of the total leadframe market to climb from the current 5% to 10% in three years. "By 1989," adds Herriges, "almost all we do will be SMT."

"We see near-term continued growth in SMT, quads, and small outlines," says Shinko's Cruickshank. "Maybe 20%. The limiting factor is capacity. Our factory in Japan is all booked up." Shinko reports no expansion plans, although it is adding more equipment at its Manteca, Calif., plant. □

The worldwide wafer fabrication materials market could grow 20%

($ millions)

	1988	1989	1990
Silicon wafers	$1,600	$1,824	$2,152
Other substrates	189	215	254
Photomasks	995	1,134	1,338
Photoresists			
Positive	125	142	167
Negative	86	98	116
Advanced	6	7	8
Wet chemicals	379	431	508
Gases	519	591	697
Deposition materials	203	231	272
Total	$4,102	$4,673	$5,512

Price increase added to unit increase of 10% in 1988 only

Source: Electronic Materials Report

Packaging materials up 25% as Japanese make up for the rise in yen

($ millions)

	1988	1989	1990
Leadframes	$970	$1,077	$1,164
Ceramic packages (metallized)	665	742	833
Thick film pastes	220	242	268
Encapsulation resins	412	493	616
Bonding wire	310	361	432
Sidebrip	384	389	417
Headers and cans	113	117	120
Seal lids	177	203	235
Hybrid substrates (active)	100	110	122
Hybrid packages	115	127	139
Die attach materials	74	84	97
Other	175	210	247
Total	$3,715	$4,155	$4,690

Price increase added to unit increase of 10% to reflect precious metal price increase in 1988

Source: Electronic Materials Report

BY JACK GEE

Europe: Vendors prepare for sustained growth

From chips to computers to communications, most vendors are hoping 1988 will be a year of expansion

Despite uncertainties about economic growth in the West, the continent's electronics industry is preparing for what they hope will be a prosperous year in 1988.

"We are targeting another double-digit increase in profits over the next 12 months," says Klaus Luft, chairman of West Germany's Nixdorf Computer AG. At Alcatel, the French-managed telecom group which now ranks in second place worldwide behind AT&T, president Pierre Suard comments: "Barring unforeseen hitches, the outlook for European electronics is favorable."

Orders for semiconductor devices, a reliable yardstick for measuring the industry's growth rate, confirm this mood of optimism. Sales of 1-megabit dynamic RAM chips are booming as computer and telecom manufacturers compete for limited supplies.

In response to this demand, full-scale production of DRAMs will begin this year at plants operated in West Germany by Siemens AG at Regensburg; in Scotland, by Motorola Inc. at East Kilbride and by NEC Corp. at Livingston. This "Silicon Glen" is also home to a plant where Compaq Computer Corp. is about to start manufacturing personal computers. N.V. Philips GL plans to begin producing 1-megabit static RAMs at Nijmegen in the Netherlands.

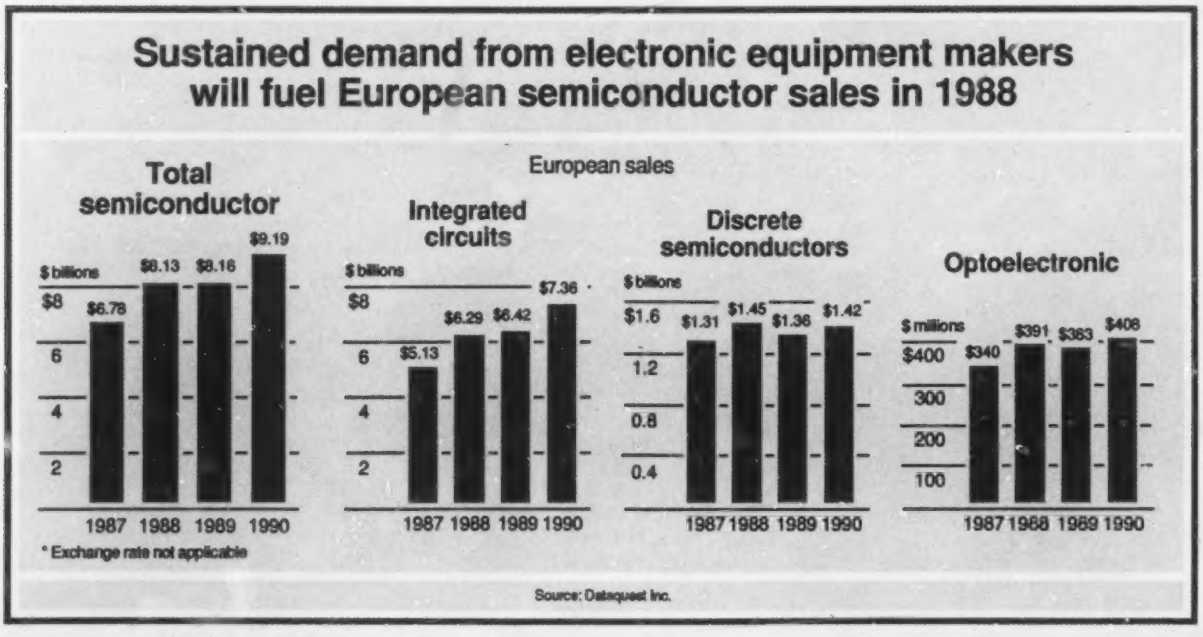
Dataquest Inc., a San Jose electronics market study group, predicts that European sales of 1-megabit DRAMs will rise from 2 million units in 1987 to 20 million units in 1988. As volume shipments of the powerful new chips get underway, sales of 256 kilobit memories are expected to drop from 100 million units to below 60 million units.

According to Dataquest, semiconductor sales in Europe last year grew by 7% reckoned in local currencies and by 23% in dollars. But James Beveridge, director of the research firm's Western Europe Semiconductor Industry Service, says: "Sustained demand in Britain, France and Italy has contrasted with flagging orders in West Germany. Growing unemployment and the high exchange rate for the yen have weakened chip sales in the Federal Republic."

Beveridge believes the upheaval on the world's financial markets is unlikely to prod European consumers into cutting back on purchases of electronic products. "In the U.S.," he says, "there has been concern that the Wall Street crisis will reduce disposable incomes. However, Europeans don't rely as much as Americans on equity revenue for their spending money. Europe can look forward to sustained growth of both electronic systems and domestic products in 1988. And that will be good news for the chip industry." There are also no immediate signs that the stock exchange confusion has prompted chip makers to make immediate cutbacks in capital investment.

Printer production

Europe's chip makers stand to gain from the repercussions of an anti-dumping suit which the 12-nation European Community has launched against Japanese printer manufacturers. To counter the risk of a boycott against their products, the Japanese are beginning to boost their produc-



tion capacity in Europe. This year, Oki Electric Industry Company Ltd. will begin manufacturing at Cumbernauld in Scotland. "And that is another shot in the arm for the European electronics industry, including the makers of the chips which Oki will buy locally," says Dataquest's Beveridge.

Japan is currently shipping into Europe 70% of the printers that it sells there. But Al Stegsteel, a Dataquest vice president and director of its Western Europe Printer Industry Service, says: "By 1990, 70% of those printers will be made by the Japanese at European plants."

Dataquest forecasts that, over the next five years, European market growth will exceed 50% for 32-bit personal computers; 30% for digital telecommunications; 60% for the microprocessor-memory "smart" card; 26% for cellular radio; and 10% for automotive electronic components. "All these markets will begin ramping up in 1988," Beveridge predicts.

But this bullish attitude by Europe's chip sellers and users does not mean that the development of its semiconductor industry will be a painless process. Pasquale Pistorio, the Italian industry veteran, faces the grim task of axing jobs and closing plants as he welds his old company, SGS Microelettronica SpA, with Thomson Semiconducteurs, France's leading chip maker, into the newly created SGS-Thomson Microelectronics group. "This marriage is the only way to create a competitive European semiconductor industry," he says. "With current joint annual sales of $800 million, Thomson and SGS together could soon join the $1 billion league." Already, the new company ranks No. 2 in Europe behind Philips.

The U.S. electronics industry will be tracking Pistorio with particular vigilance as he ponders one tough choice. The new Franco-Italian group has inherited two Stateside plants, Thomson-Mostek's older generation facility and a brand new, but empty, SGS plant. Since the chip business moved into the doldrums, Pistorio has hesitated to equip this Phoenix, Ariz., facility with production gear for micron-width devices. Industry watchers are betting that he will close down one of his U.S. factories. Whichever his choice, it will cause much heart rending.

The coming year will also be a testing time for Europe's telecommunications firms which, in 1987, joined forces in a series of alliances to challenge their U.S. rivals. Indeed, at long last, it is fair to speak of a European telecom industry rather than a disparate medley of small manufacturers which, until recently, depended almost entirely on protected home markets for sales.

To confront AT&T, which has gone into harness with Philips' to market its central office switches, Alcatel, the French telecommunications equipment group, pulled off a $1.3 billion deal in 1987 to acquire most of the European activities of ITT. AT&T tried to recoup by bidding against Siemens for Compagnie Générale de Constructions Téléphoniques, an ailing French switch maker. Eager not to antagonize either the United States or West German governments, the French decided to sell CGCT to a partnership between its own state-controlled Matra group and Sweden's L.M. Ericsson.

In Italy, negotiations toward a joint venture between the country's two leading equipment manufacturers, Italtel and Fiat's Telettra, broke down in November after Fiat refused to accept Italtel's president, Marisa Bellisario, as chief executive officer of the combined operation. The negotiations, which had lasted for two years, were intended to pool the two companies' telecom businesses into a single operation called Telit.

Germany's Siemens, among other

Home is where the PC is

The past year has been marked by the arrival in the European home of the personal computer which, until recently, had been confined to the office.

"When the Sinclair home computers took the market by storm they were clearly designed for hobbyists," says Gordon Curran, joint founder and managing director of Intelligent Electronics Europe, a research company recently acquired by Dataquest Inc. "But nobody seems to be clear what role the PC is going to fill in the family drawing room. It's certainly not child's play to operate a desktop computer —particularly when professional motivation is absent."

The current surge in PC sales in Europe owes much to Alan Sugar, chairman of Britain's Amstrad Plc, who has made a spectacular entry into his local markets with a family of low-priced MS/DOS models. Sugar hoped to sell 700,000 of them in 1987. But sales lagged at around 250,000. However, Amstrad has now squeezed Ing. C. Olivetti & Co. out of second place behind IBM in the European market, according to Intelligent Electronics.

Sales of PCs in Europe grew by 40% to 2.6 million units last year from 1.8 million units in 1986. Curran, who predicts growth for 1988 of 27%, attaining 3.3 million units, says: "Amstrad has stimulated this new wave of interest in personal computers."

A change in retailing methods accompanies this boom in European PC sales. The desktop machines, until recently marketed by specialized stores, are now increasingly sold through mass merchandise outlets. Curran says: "In 1986, the type of shops that sell radio and hi-fi systems accounted for only 7% of Europe's PC sales. But last year, they sold 18% and, in 1988, it is likely they will handle 25%."

IBM, which supplied 25% of Europe's PCs in 1986, has maintained this share of the expanding overall market. Large businesses are gobbling up its new Personal System/2 range machines as fast as they come out of the factory at Greenock, Scotland. Thanks mainly to the PS/2, IBM's share of big account business for PCs which dropped from almost 60% of the European market in 1985 to 40% in 1986, rose to almost 50% again last year, according to Intelligent Electronics' estimates.

Although it has slipped into third place in Europe's PC stakes, Olivetti seems well positioned to move up from being a box producer to the role of systems supplier. This new strategy has been signalled by its recent introduction of a promising range of minicomputers. Curran says: "In 1988, we shall be looking at a much more professional Olivetti."

Like Olivetti, Nixdorf Computer AG is steadily consolidating its presence in the European market by offering both minis and micros. □

companies, had expressed interest in membership. Luis Solana, president of Telefónica, the Spanish national telephone carrier, was also enthusiastic to sign on. Solana had said that Telit "could be the first genuine European effort in telecommunications." The disruption in negotiations is considered by industry watchers to be a major setback in Italy's efforts to pull its communications industry together.

The mushrooming of more powerful industrial groups could be a golden opportunity for Europe's telecom industry. Another big chance lies in Integrated Systems Digital Network (ISDN), the technology that allows data, pictures and print to be transmitted like ordinary phone conversations over the phone network. But these great expectations will be doomed, unless European governments open their borders to outside suppliers. Only Britain has so far shown any genuine willingness to follow this path.

The watchdog Commission of the European Community is urging its member nations to encourage greater competition in the supply of both equipment and data services. Lip service to this objective will soon have to give way to action. By 1992 the Community has undertaken to sweep away its internal obstacles to trade and create a genuine Common Market of 320 million consumers.

Europe's tortoise-style speed of high-tech product development was condemned recently by Jacques Stern, chairman of Groupe Bull, the French computer group, at a conference on Esprit, the European Community's program of research in information technology. Recalling that the high-tech gap between Europe and its Japanese and U.S. rivals remains as wide as ever, Stern said: "European industry is virtually a nonstarter in supercomputers, microprocessors and computer storage devices."

The veteran manager called for research projects to be put under the management of Europe's major electronics companies. Until now, these have been the responsibility of deskbound bureaucrats at the European Community's Brussels headquarters. The appeal by the Bull chairman for a hard-headed, market-oriented approach addresses an urgent issue. But, unless Europe's governments and manufacturers coordinate their efforts, Stern's is likely to remain a voice in the wilderness. □

BY PAULA DOE

The Far East: Beware of the baby dragons

Following in Hong Kong's footsteps, Singapore, South Korea and Taiwan are newly developing Asian powers

Asia's electronics industry will pace world growth again in 1988. As the four dragons — South Korea, Taiwan, Hong Kong and Singapore — prosper, making the things that used to be made in Japan, growth is spilling over into the next tier of less industrialized, lower-wage Asian countries from Malaysia to Thailand.

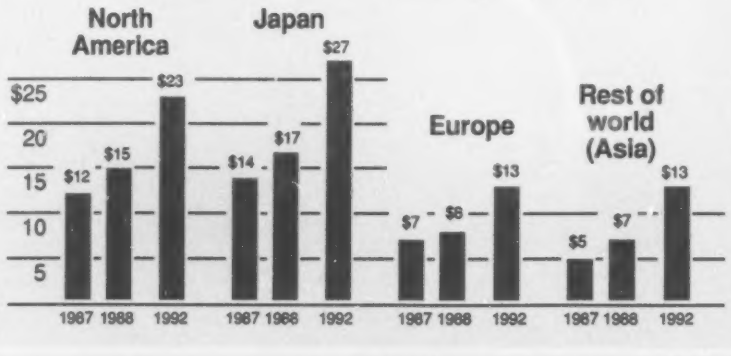
Consumption of semiconductors in Asian countries other than Japan will surge 42% this year, on top of 68% growth in 1987, according to Dataquest Inc. projections. "It's too early to tell what the effect of the stock market crash will be, but even if the U.S. market slows, compared to the U.S., Asia will still do better," claims Tom Wang, who tracks Asian markets for the San Jose market research firm. That means Asian electronics companies, which used a mere $2.9 billion worth of semiconductors in 1986, will use $6.9 billion worth in 1988. By 1992, Dataquest sees a $13 billion Asian semiconductor market — that's as big as the U.S. market in 1987.

Lower stock prices will slow down the Japanese economy too, but 1988 should still be a respectable year. Most producers are starting to see the results of their drastic cost cutting and restructuring to cope with the high yen and are starting to make money again. And domestic demand is finally starting to replace exports in driving economic growth. Dataquest sees 20% growth in Japanese consumption of semiconductors in 1988, after an anemic 1% increase, measured in yen, in 1987. World Semiconductor Trade Statistics Inc. projects Japan's shipments of semiconductors will climb 15.9% in 1988

As more components are used in Asian factories, more will be made there too. "People will be building lots of fabs in Asia in the next few years," points out Wang, ticking off a list of six planned semiconductor

Asian electronics industry will use as many chips as Europe by 1992

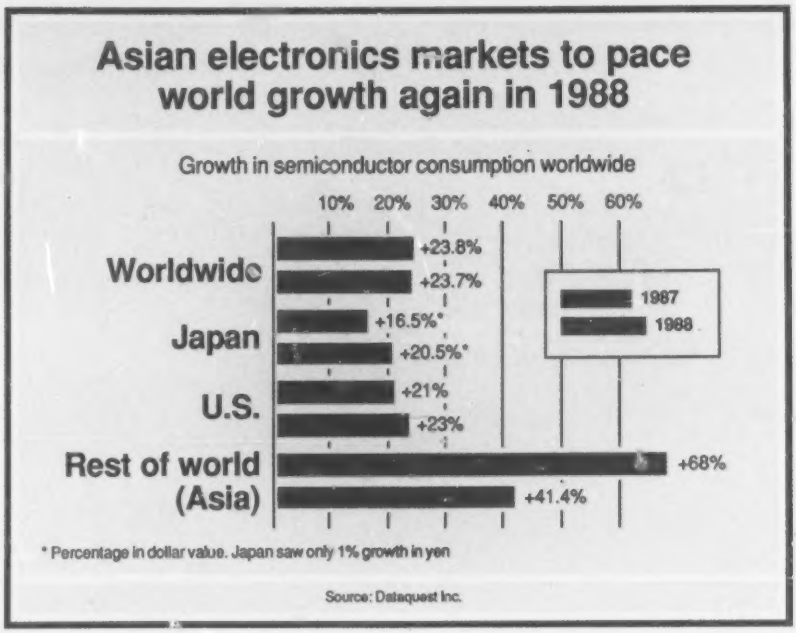
Worldwide consumption of semiconductors ($ billions)



Source: Dataquest Inc.

fabrication plants that come immediately to mind. "There will be lots of opportunity for suppliers of equipment and materials too."

Although a slowing of the U.S. economy could slow the high-speed growth of the Asian electronics export industry, steady long-term growth in the region still means healthy local demand for industrial equipment and business systems throughout Asia. "Before, they didn't care about personal computers," says Wang. "Now that they're rich they want the advanced models."



The Korean card

Korea's plans to upgrade its financial sector, for example, will mean major computer purchases, as will its $400 million program to computerize government agencies. A plan to start computer education in Korean schools in 1989 is expected to spur sales of personal computers. Malaysia has budgeted around $25 million a year for bringing computers to government agencies. A number of countries plan to upgrade their telecommunications systems. "Given their stage of development," notes a government trade official who, like all the trade officials interviewed, prefers not to be identified, "These should be very lucrative markets."

Also spurring Asian electronics growth in 1988 is the rapid expansion of electronics production outside of the four dragons.

The influx of business to Korea, Taiwan, Singapore and Hong Kong has pushed up wages, prices and exchange rates in those areas in recent months. In Korea, wages were up about 20% over 1987. Labor shortages in Singapore are pushing wages for assembly workers up 2% to 4%, and salaries for engineers are up 6% to 8%. The Taiwanese currency has appreciated about 20% against the U.S. dollar.

"These aren't low-wage countries anymore," points out Christopher Mead, editor and publisher of the Southeast Asia High Tech Review in Phoenix. "The per capital income in Hong Kong will be higher than that in its old colonial master, Great Britain, by 1990." Per capita gross domestic income in Taiwan leaped from approximately $3,000 in early 1986 to around $5,000 at the start of 1988.

Korean exchange rates and wages will have to go up too," predicts Mead. "How long can it continue — [with] workers in Korea working just as hard as workers in the U.S., using the same equipment, for $2 an hour?"

Taiwanese electronics producers are now joining the Japanese in fleeing high exchange rates and looking for low-cost assembly labor in Thailand, Malaysia, the Philippines and Indonesia. Thailand's Board of Investment reports 105 Japanese applications for foreign investment in the first half of 1987, twice the number for all of 1986. But now in Taiwan too, every month sees a spate of local producers announcing plans to move production elsewhere in Asia. One recent month saw Sampo Corp. announcing it would make color televisions in Thailand, K T Electronics Corp. announcing it would make loudspeakers in the Philippines, and Rectron Ltd. announcing it would make silicon rectifiers in Malaysia.

This year should also see some Asian markets opening up a little more to U.S. companies.

Lowered trade barriers

Korea removes its import licensing restrictions on computers this year, so users can now buy foreign-made equipment without having to certify that nothing comparable is made in Korea. Tariffs drop from 20% to 25%, down to 15% to 20%. To ensure that the new rules help the United States, as intended, no Japanese personal computers will be allowed. One trade official notes that, "this should make it easier to sell mid-level machines, especially to government agencies, where price is not as big an issue as it is in the private sector."

Indonesia is also opening up its computer industry a bit in an effort to stimulate growth. Government agencies no longer have to buy computers only from the short list of approved vendors. Components can be imported free of tariffs, while import fees on finished products are down to 50% to 60%.

Government trade officials involved in negotiations with Japan expect the Japanese to buy more U.S. supercomputers in 1988. Last August's agreement making the process of purchasing supercomputers more transparent, combined with continued Japanese government pressure on Japanese supercomputer makers to stop drastic discounting, should make it easier for those Japanese institutions interested in buying U.S. supercomputers to do so.

Trade officials are also optimistic about sales of telecommunications equipment to Japan, despite some disappointment in the results of the celebrated telecommunications sector agreement of a few years ago, which was intended to open up the market. Notes one official involved, who prefers not to be identified, "We made regulatory changes that you would expect would lead to increased sales, on paper. But in practice, actual sales have fallen short. What actual sales there have been are probably from the yen appreciation and private efforts, as much as from changes in the rules." □

DATABASE

Recovery still on for computer market

The Federal Reserve Board released its annual revisions to industrial production during the third quarter of 1987. The data from 1985 to the present now reflects the addition of new data not previously available and new seasonal factors. Growth rates were revised downward for most categories of high-tech production. Only computers and office equipment production underwent significant upward revision, from 3.8% to 6.4% in 1985, and from -3.2% to -1.3% in 1986.

In 1987, production dropped off slightly in August from July, but it was still up 6.7% from August 1986. On a seasonally adjusted basis, new orders for computers and office machinery for the month of September were running 8.4% above the same month in 1986 and, at $41.9 billion for the first three quarters combined, were 5% above the comparable period of the prior year.

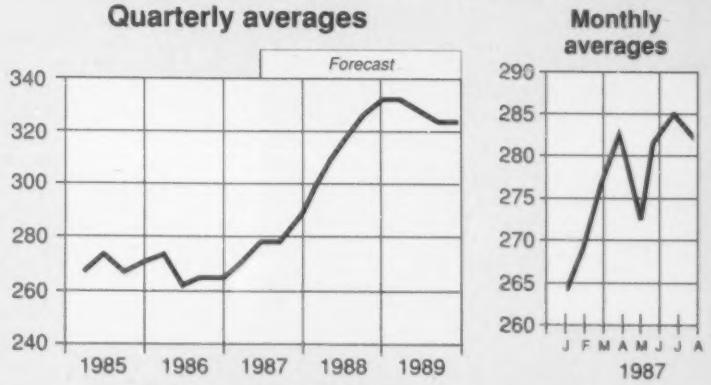
Growth rates for shipments continued to indicate clear signs of improvement. While the values of shipments for the first and second quarters were below the same quarterly levels in 1986, shipments for the third quarter stood at $14.7 billion, an increase of 3.6% compared to the third quarter 1986.

Edited by LINDA STALLMANN

More information can be obtained from Madeline Franchi, senior economist, Cahners Economics Department, 275 Washington St., Newton, MA 02158 Phone: (617) 964-3030.

Industrial production index for computers

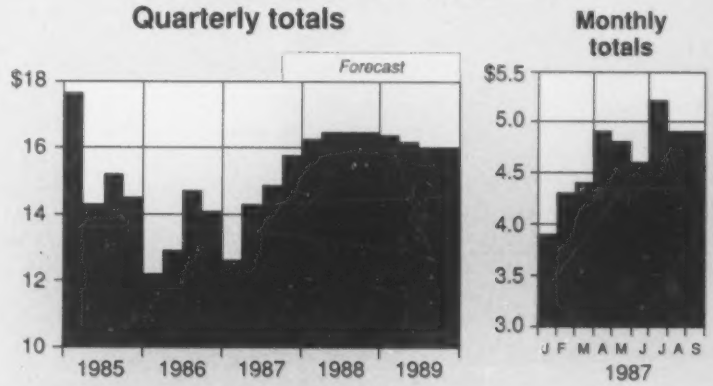
Seasonally adjusted index (1977=100)



Source: U.S. Department of Commerce; Forecast: Cahners Economics

New orders of computers

Seasonally adjusted (Current $ billions)



Source: U.S. Department of Commerce; Forecast: Cahners Economics

Computer market database

	Latest month	Previous month	Change	Year ago	Change	Next year	Change
Industrial production (SA, 1977=100, August)	283.4	286.4	-1.0%	265.6	+6.7%	328.2	+15.8%
Shipments (SA, $ millions, September)	$4,925	$4,875	+1.0%	$4,703	+4.7%	$5,623	+14.2%
New orders (SA, $ millions, September)	$4,858	$4,857	+0.02%	$4,480	+8.4%	$5,514	+13.5%
Unfilled orders (SA, $ millions, September)	$19,191	$19,258	-0.3%	$19,351	-0.8%	$21,287	+10.9%
Inventory-to-shipment ratio (SA, September)	1.93	1.97	—	2.17	—	1.88	—
All employees (thousands, September)	457.6	458.6	-0.2%	468.6	-2.3%	495.53	+8.3%
Production workers (thousands, September)	151.8	150.8	+0.7%	156.5	-3.0%	162.27	+6.9%
Exports ($ millions, August)	$1,482	$1,422	+4.2%	$1,298	+14.2%	$1,664	+12.3%
Imports ($ millions, August)	$1,589	$1,600	-0.7%	$1,172	+35.6%	$1,711	+7.7%

SA = seasonally adjusted, all other data is not seasonally adjusted

Data sources: Federal Reserve Board, U.S. Bureau of the Census and U.S. Bureau of Labor Statistics
All data for SIC 357, except industrial production, SIC 357-9. Forecasts: Cahners Economics

SEMICONDUCTORS

4Mb DRAMs: Tough to make; tougher to sell?

The big memory chips promised a 1987 debut. But production and pricing issues make volume sales unlikely before 1989

By Michael R. Leibowitz

In the beginning of 1987, it looked to all the world as if the 4Mb dynamic RAM chip was going to arrive early. At February's International Solid State Circuits Conference (ISSCC), one vendor after another unveiled working 4Mb designs, Japan's Nippon Telephone and Telegraph previewed its 16Mb design, and an IBM presenter announced to a shocked conference audience that his company would be entering 4Mb production during the second half of 1987.

In the months that followed, companies began promising 4Mb DRAM samples by the end of 1987, and the chip makers appeared ready to break a rule that has held for five generations of DRAMs, a rule which says succeeding generations of DRAMs arrive at precise three-year intervals.

Should electronic equipment makers brace for a flood of 4Mb DRAMs in 1988? Probably not. Vendors have pushed out early projections for the new generation part, but more importantly, a number of barriers exist to slow the emergence of the part, rather than accelerate it. "1988 will be a showcase year," where vendors posture and parade their samples before customers, says Victor Dedios, an analyst with Dataquest Inc. in San Jose. Look, instead, toward 1989 as the year that the 4Mb DRAM hits the streets as a production part.

Virtually all of the current DRAM makers have joined the race to produce 4Mb parts. American DRAM makers Micron Technology Inc. and Texas Instruments Inc., and Japanese firms including Fujitsu Ltd., Hitachi Ltd., Matsushita Electric Industrial Co., Mitsubishi Electric Corp., NEC Corp., Oki Electric Industry Company Ltd. and Toshiba Ltd., each have active 4Mb development programs and most have produced working samples in the laboratory. Furthermore, some of these chip makers will have the capability — if they choose — to make production quantities of the part during the second half of 1988.

THE MARKET

But the question of how fast vendors will ramp up the 4Mb DRAM depends more on business and economic issues than on the availability of technology and the headlong dash to grab market share. The losses suffered by companies during 1984 through 1986 have instilled a profit consciousness in the minds of many DRAM players. And in those where it hasn't, fair market value (FMV) controls — which assign minimum cost-based prices for DRAMs — should prevent frenzied grabs at market share and force all chip makers to play the DRAM game more rationally and profitably.

Making DRAMs has become an incredibly expensive business as R&D and capital equipment costs skyrocket with each new generation of part. Chip makers face a considerable investment in order to enter production on the 4Mb — on submicron equipment at $1 million per machine; on new ultra-clean facilities; and on a potentially difficult ramp-up to get suitable yields.

Meanwhile, success in the DRAM business means progressing down the 4Mb production learning curve early and introducing the part while it can still fetch handsome prices on the market. But increasingly, it also means not obsoleting a highly profitable part before its time. And today, the profitable part in question is the 1Mb DRAM.

Chip makers are finally starting to make money on the 1Mb DRAM, and many chip makers are understandably reluctant to interrupt the performance of a part which is finally paying off its capital investment, contributing to profits, and making some company executives glad that they are still in the DRAM market.

Where does that leave the ramp up of the 4Mb DRAM? "It's a compli-

1988 will be the "showcase" year for 4Mb DRAMs; after that, users will start to buy

Worldwide unit sales (millions)

Year	Units	Likely users
1988	—	Sampling only
1989	3-4	Technical workstation makers
1990	50	Mainframe computer makers
1991	400	Personal computer makers

Source: Dataquest Inc.

cated question," says Gregory Armstrong, manager of metal oxide semiconductor (MOS) memory development at Texas Instruments Inc. "The whole issue of how the 4Mb plays against the 1Mb is yet to be answered."

A rapid erosion of prices on 1Mb DRAMs could certainly convince chip makers to gear up early on the 4Mb so that they can shift production emphasis to a more lucrative product. But the 1Mb is unlikely to become the subject of a chip war — FMVs prevent that by linking vendors' price reductions to manufacturing cost reductions.

FMVs for the 4Mb DRAM, if established, will also dramatically influence the rate at which the 4Mb makes a full-scale entry into the DRAM market. The absence of FMV controls on the 4Mb could tempt some memory makers to try to gain market share by introducing the part early at low prices. On the other hand, too high an FMV will delay the ramp up of the 4Mb for lack of customers willing to spend $150 or more on the part.

Lawrence Hester, MOS memory marketing manager at Fujitsu Microelectronics, says that Fujitsu is poised to begin production of the 4Mb DRAM in the third quarter of 1988. "Whether it's even advisable to do so will depend on what pricing is set by the U.S. government," says Hester.

Although the agreement establishing FMVs covers all DRAM generations after the 64K DRAMs units, it is not yet clear whether the Department of Commerce will assign FMVs to early 4Mb parts.

One of the questions Commerce officials will be trying to answer in determining 4Mb FMV pricing will be what costs to base the new product's price structure on, according to William Krist, vice president of international affairs for the American Electronics Association. U.S. firms like to amortize much of their R&D costs into the early production shipments, while Japanese chip makers tend to distribute the costs to other operations within their vertically integrated companies.

Although it is too early to tell for certain, many experts believe that, if necessary, FMVs will be established for the 4Mb to slow it down. There is much evidence to suggest that 1Mb DRAMs will bring sustained profits for DRAM manufacturers in 1988. And if anything, only a small number of early production 4Mb parts will find their way into the market before 1989.

1989 will see 3 million to 4 million units shipped, according to Dataquest — with most of the shipments skewed toward the second half of the year. 1990 will see 50 million units shipped, with 1991 topping 400 million.

Technical workstation makers, eager to pack the latest performance and density improvements into their machines, will be the earliest users of the 4Mb DRAM, predicts Dataquest's Dedios. Mainframe makers will begin using the chip next, followed by personal computer manufacturers in 1991, when the price per bit of the 4Mb will match that of the 1Mb.

Chip makers say that the access time of the 4Mb, while initially coming in at around 80 nanoseconds (ns), will eventually hover around the 60 ns mark, as they tweak their fabrication processes.

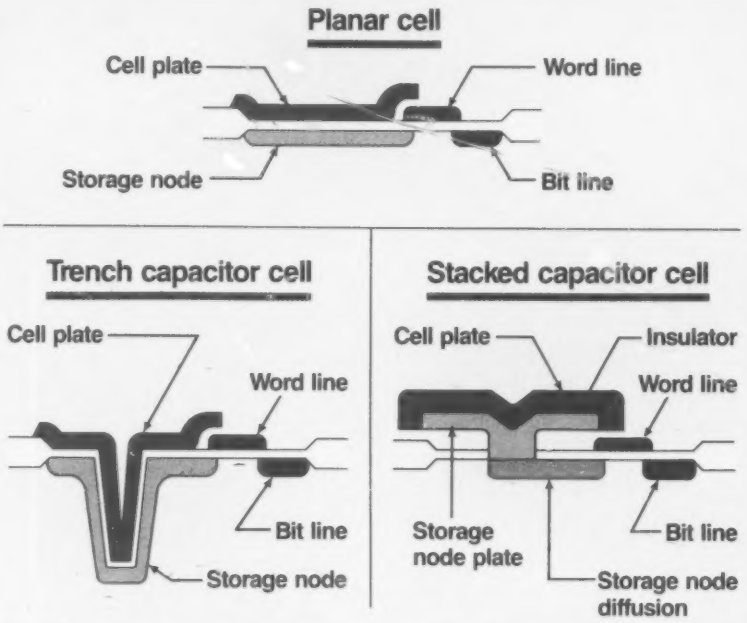
Most chip makers intend to package the 4Mb chip as a drop-in replacement for the 1Mb, in a 300-mil dual in-line package (DIP), 300-mil small outline J-leaded (SOJ), and 350-mil zig-zag in-line package (ZIP). Many manufacturers expect DRAM demand to shift from the DIP to the high-density SOJ and ZIP packages as the 4Mb market grows.

THE TECHNOLOGY

Chip makers face two significant technical challenges in bringing up production of the 4Mb DRAM. One is mastering the art of submicron chip fabrication. The other challenge involves perfecting techniques for

Dynamic memory-cell evolution

In the same way that real estate developers begin building vertically as land prices increase, chip makers have found that building below or above the chip's surface is an effective way to squeeze more memory-cell capacity onto a given die area. As demand for bigger memory chips increases, the older planar design is giving way to three-dimensionnal chip-making techniques. The most popular of these is "trench" technology, already used in 1Mb chips, where a hole is dug into the chip substrate and the walls of the hole are then coated with the charge-storing dielectric material. In the second technique — the stacked cell —the capacitor part is stacked directly on top of the planar cell transistor, still saving space while avoiding the difficult task of building a trench. Both techniques will be essential to fabrication of 4Mb DRAMs. □



Sources: Fujitsu Microelectronics and Texas Instruments

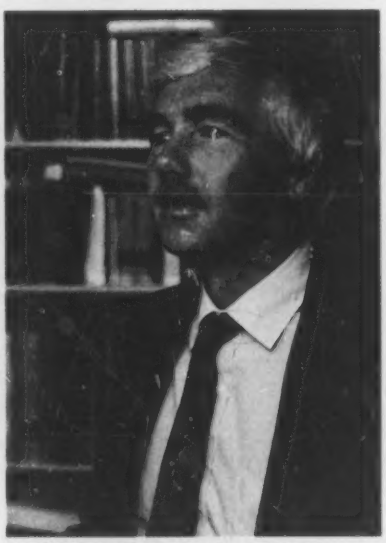
TEXAS INSTRUMENTS' GREGORY ARMSTRONG: Wondering how a fast ramp-up of the 4Mb DRAM would affect successful sales of 1Mb memory chips

building DRAMs using some type of space saving three-dimensional storage element.

Most DRAM makers will be building early production 4Mb parts with minimum transistor gate lengths of between 0.8 and 1 micron. Yields, and hence manufacturing costs, will depend on how well they control line widths and mask registration, and on their ability to reliably deposit multiple levels of metal interconnect materials onto a bumpy chip surface. They will have to master the use of new and sensitive submicron optical stepper-and-repeat imagers, ion implanters, dry-etch gear and chemical vapor deposition equipment. Finally, they will have to understand how to form transistors with the profiles necessary to minimize the destructive effects of hot electrons.

But the real challenge is to avoid increases in so-called "soft error" rates as the chip's features are downsized. On a memory chip, the cell capacitors that store the electrical charge occupy most of the space of the storage cell. Each cell, comprising the capacitor and a transistor element, stores one data bit. And collectively, the storage cells take up 45% of the chip's area. The difficulty lies in shrinking the capacitor's size without lowering the storage charge enough to make it vulnerable to soft errors, where the charge is wiped out by stray radiation particles.

The solution to the problem of reducing the area occupied by the storage cell while keeping its charge constant is to build a three-dimensional cell in place of a conventional planar cell. In the same way that real estate developers begin building vertically as land prices increase, chip makers have found that building below or above the chip's surface is an effective way to squeeze more cell capacity onto a given die area.



FUJITSU's LAWRENCE HESTER: Is poised to begin production of 4Mb DRAMs in the third quarter of 1988

By far, the most popular three-dimensional cell design involves digging a hole into the chip substrate, coating the walls of the hole with a dielectric material and storing charge there. This "trench capacitor" can be dug deeper to increase density, and memory designers believe that it can be used in 16Mb DRAMs as well. While some chip makers attempted to build trench capacitors for their 1Mb DRAM designs, many encountered difficulty in forming the trench and decided to wait for the 4Mb to shift to the newer technology. Two firms, TI and NEC, have been using trench capacitors successfully in 1Mb production DRAMs. Both firms say they will incorporate the cell transistor — the other part of a memory chip's storage cell — into the trench as well, for additional space savings.

The stacked capacitor cell is the other three-dimensional cell design. It stacks a capacitor directly on top of the planar cell transistor, still saving space while avoiding the difficult task of building a trench. Advocates of stacked capacitors say that the design exhibits a slightly lower soft error rate. Critics say that its capacitance is limited and cannot be used beyond the 4Mb density. Users will see little difference between the two designs, however.

Generally, chip makers plan to introduce 4Mb chips in whatever process will allow them to fit the die into

the same 300-mil packages used for the 1Mb models. Later, as their experience with submicron processes and trench cells increases, DRAM builders say they seek cost savings by shrinking their parts to transistor channel lengths of 0.7 micron or 0.8 micron.

COST OF ENTRY

The good news for users of the new mega-memory chips is that the pin layout and package of the 4Mb DRAM is compatible with the 1Mb unit. Equipment makers need only route two extra data lines to their boards' memory arrays in order to drop in 4Mb DRAMs when they become available.

The bad news is that the 4Mb will be very expensive initially. William Shrum, tactical marketing manager at NEC, projects that their price at the end of 1988 will be $150. Other chip makers project even higher price tags.

Prices for the 4Mb will most likely start approaching reasonable levels during the second half of 1989, when many producers begin volume shipments. Dataquest's Dedios pegs their average prices for 1989 at $35, but is reluctant to hazard a guess for 1990. He does believe the 4Mb will reach parity with its 1Mb sibling on a cost-per-bit basis during 1991.

THE COMPETITION

The sampling schedules for the 4Mb DRAM are probably the worst criteria to use for assessing its availability. Each competitor is concerned about appearances and has promised to show samples of technical prowess in 1988, or late 1987 at the earliest. What holds true for chip making in general is particularly relevant to the 4Mb generation: A company's ability to generate samples and ramp up production are two very different things.

Fujitsu, Matsushita, NEC, TI and Toshiba say they will be in production on the 4Mb DRAM by the third or fourth quarters of 1988. For these and other companies attempting early entries into the 4Mb market, factors that may encourage early success include experience in building the big chip's three-dimensional cell capacitor and experience in 4Mb process technology.

TI appears to have a lead in these regards. The company has the benefit of experience in building trench capacitors for its 1Mb DRAM, a factor which should reduce the probability of snafus on its bigger memory part. TI will be trying something new on its 4Mb DRAM, however, by adding a trench *transistor* that will minimize cell area and die size further. But TI is counting on this to lower risks rather than increase them, by allowing the company to fabricate the part on its 1 micron process — the same process used for its 1Mb part — rather than having to bring up a submicron process to achieve the same die size. TI can then move into submicron production on a more relaxed schedule. The company expects to have samples of its 4Mb DRAM in the middle of 1988 and to begin production in the fourth quarter.

Tim Davis

WILLIAM SHRUM, NEC's tactical marketing manager, is projecting a price of $150 for 4Mb DRAMs at the end of 1988

James Caccavo

TOSHIBA AMERICA's JAY LITUS: Hoping that his early lead in Mb DRAMs will help give Toshiba the edge in 4Mb production

NEC also has experience in making trench capacitors for its 1Mb chip. Despite this, the company is taking a conservative approach to the 4Mb business. It is planning two iterations of the part. The first will be a slightly shrunk, 4Mb extension of its 1Mb part, although assembled in larger packages. This nonstandard part should be available in the second half of 1988, according to the company. The second part, packaged in standard 300-mil DIP, 300-mil SOJ and 350-mil ZIPs, will be a total redesign, incorporating a trench transistor along with its trench capacitor and fabricated on a 0.8 micron or finer process.

NEC says that it expects most customers will wait for its second iteration, available at the end of 1989, rather than start early with its larger, nonstandard part. So why are they bringing out the first iteration in the first place? "It's a 'me too' kind of approach," says NEC's Shrum. "No one wants to be the last one out with the 4Mb."

Toshiba's early lead on the 1Mb DRAM may give it production edge

on the 4Mb chip, even though it will be implementing its trench design for the first time. The company is readying a submicron 4Mb part for production in the third quarter of 1988 and will be running the part on the same lines as its 1Mb DRAM, according to Jay Litus, Toshiba America's director of marketing. "The thing that we bring to the party is [an ability] to make it a production reality as soon as possible," says Litus. Toshiba has already produced second-generation working silicon of its 4Mb part.

Motorola expects to manufacture 4Mb DRAMs, but not right away, says Weldon Knape, marketing manager for Motorola's general memory operation. In accordance with its technology and marketing agreement with Toshiba, Motorola will initially package and test Toshiba parts for first shipments in early 1989. The company then expects to bring up its own 4Mb chip production — using Toshiba technology — sometime after that.

Other chip makers claim they are well along in the production process and that they expect no glitches in beginning production on schedule.

THE OBSTACLES

More than two and a half years will have elapsed between the time the first 4Mb DRAM paper was presented at the 1986 ISSCC and when the first production parts hit the market in the back half of 1988. This illustrates how complex this business has become. Never before have DRAM makers faced such harsh economic decisions, technical challenges and regulatory questions in bringing a new product to market.

The actual timing of the 4Mb DRAM will depend on all these issues, although one thing seems almost certain: The big chip will not arrive early. It will, perhaps coincidentally, arrive in the same three-year cycle that has characterized the DRAM business since the advent of the 4K chip. For the 4Mb DRAM, 1988 will look remarkably like 1985 for the 1Mb model. □

Chip makers' 4Mb DRAM schedules

Fujitsu

Samples: 1st quarter 1988
Production: 3rd quarter 1988
Fabrication technology: .7 micron CMOS
Design: Stacked capacitor
Die size: Not available

Hitachi

Samples: 1st quarter 1988
Production: 1st quarter 1989
Fabrication technology: .8 micron CMOS; 2-level metal, 3-level poly
Design: Stacked capacitor
Die size: 232 mils by 606 mils; (140,592 square mils)

Matsushita

Samples: 1st quarter 1988
Production: 3rd quarter 1988
Fabrication technology: .8 micron CMOS
Design: Trench capacitor
Die size: 179 mils by 582 mils; (104,178 square mils)

Micron Technology

Samples: Second-half 1988
Production: 1st quarter 1989
Fabrication technology: .85 micron CMOS
Design: Not decided
Die size: Not available

Mitsubishi

Samples: 1988
Production: 1989
Fabrication technology: Not decided
Design: Not decided
Die size: Not available

Motorola

Samples: 1st half 1989
Production: 1st half 1989
Fabrication technology: Using Toshiba's technology

NEC

Samples:
First iteration: 1st quarter 1988
Second iteration: 3rd quarter-4th quarter 1988
Production:
First iteration: 4th quarter 1988
Second iteration: 4th quarter 1989
Fabrication technology:
First iteration: .9 - 1.0 micron CMOS; 1-level metal, 2-level poly
Second iteration: .8 micron or finer CMOS
Design:
First iteration: Trench capacitor
Second iteration: Trench capacitor; trench transistor
Die size:
First iteration: 244 mils by 630 mils; (153,720 square mils)

Oki Semiconductor

Samples: 4th quarter 1988
Production: 2nd quarter 1989
Fabrication technology: .8 micron CMOS
Design: Stacked capacitor
Die size: Not available

Texas Instruments

Samples: Mid-1988
Production: 4th quarter 1988
Fabrication technology: 1-micron CMOS; 2-level metal, 2-level poly
Design: Trench capacitor; trench transistor
Die size: 200 mils by 623 mils; (124,600 square mils)

Toshiba

Samples: 4th quarter 1987
Production: 3rd quarter 1988
Fabrication technology: Trench capacitor
Design: .8 micron
Die size: 255 mils by 587 mils; (149,685 square mils)

Sources: Company reports

Of electronics ups, downs, leads and lags

U.S. electronics markets lag the economy by a year, and the stock market by even more

By Alberto Socolovsky

I wish more people in the electronics industry had followed Tom Temin's example and had been far away from the newscasts last October 19. The following day, while in the Sinai Peninsula on vacation, Tom visited St. Catherine's monastery at the foot of the mount on which tradition holds that Moses received the Law. Tom, our colleague and chief editor of *Electronics Purchasing* magazine, was briefed there by an English-speaking monk about the stock market crash of Oct. 19. Not that this bit of secular business would affect the good monk's lofty affairs — the monastery has been there before there were any market crashes, and will presumably be there after many more.

Normally, we are thankful when industry executives are around when we call for their opinion on the electronics market. This time, however, a few well-timed and probably also well-deserved vacations would have made our life a lot easier. Or, if the stock market had to crash and they just couldn't follow Tom to a place so shielded from the news, I wish the market had chosen a different date to crash. Late October, you see, is when we canvass industry executives about their opinion on business conditions for the following year. Last October, after the Wall Street crash, it was like trying to detect the Pioneer spacecraft's faint signals during a sunspot storm. Even those who don't believe that there is any connection between the Dow Jones and their business devoted the interviews to explain why they don't believe it.

There is a connection, if for no other reason than that people believe the stock market is important enough to keep it foremost in their minds. But it is important to keep the connection in mind when planning because it is of a long-term nature.

The stock market is one of several leading indicators of the economy. There are others, although they don't get nearly as much publicity. The Cahners Economics department, for example, uses three leading indicators (the Dow Jones Industrial Average, housing starts and interest rates) to build the Cahners Early-Warning Indicator. Those leading indicators bear some relation to what the economy, as measured by the gross domestic product (GDP) will be doing in the future. And, since consumer spending accounts for almost two-thirds of the GDP, the stock market may be telling us today that U.S. consumers may be spending less sometime next year.

This is bad news for manufacturers of consumer electronics products, because the United States is the largest market in the world for these products. According to the Electronic Industries Association, the consumer electronics market here was worth $30 billion last year, and may go up to $32 billion this year. But less than half of these dollars are produced in the United States; most go to manufacturers in the Far East. On the other hand, more than two-thirds of the electronic equipment produced here is commercial. The markets for such equipment lag the GDP by one year. Therefore, what the stock market is telling us now is that business for most U.S. electronics companies may slow down in 1989. That's not as much time as St. Catherine's monastery has, but enough to plan for the slowdown. □

U.S. production of electronic equipment

($ billions)

	1987	1988
Commercial*	$127	$145
Military	52	54
Consumer	16	18
Total	$195	$217

* Communications, computer, industrial, instruments, office and automotive

Source: Henderson Ventures